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NOTICE TO CONTRIBUTORS

Rising costs have forced the printers to increase the charge for reprints. Beginning, therefore with the April, 1944, issue the new price schedule will be in effect. Contributors may consult the new schedule, which appears on the inside back cover of this issue, and note the increase before placing their orders.

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The War and the Future of Entomology

Presidential Address Fifty-fifth Annual Meeting, American Association of Economic Entomologists

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Today marks the second anniversary of the attack on Pearl Harbor. The Nation has been engaged for two arduous years in the most comprehensive war in the history of civilization. War activity covers every corner of the globe. Our armed forces are engaging the enemy and conducting the various aspects of this far-flung conflict under nearly every conceivable climatic condition and ecological environment. The manpower resources of the country are being severely taxed to meet the various demands, military and civilian, made upon them. Pressure for supplies and food is increasing not only for the military but also for civilian populations. Shortages of materials and equipment for many necessities have occurred and are continuing. Substitute materials to replace those especially wanted for critical uses and new methods more economical of manpower or materials, or to meet entirely new conditions, are required. The call on the scientific men and facilities of the Nation for immediate solutions of pressing problems never before has been so varied, so urgent and so insistent. Entomology has shared with other sciences this unusual and imperative demand.

Although war is the great destroyer, it is also the great catalyzer. It stimulates advancement in certain technical fields beyond that occurring during similar periods of peace. The very novelty and urgency of its requirements result in developments in new fields and along new lines. These are tested on a grand scale without the usual long period of trial, albeit with much waste. The field of entomology has felt this stimulation directly and will be benefited indirectly by its results in other fields of science and technology. It is appropriate at this time to consider the wartime developments that have occurred, or are now in progress, and attempt, without entering the precarious field of the fortune teller, to evaluate in a preliminary way their possible influence on the future of entomology.

EFFECT OF THE WAR ON RESEARCH.—Previous to the entry of the United States into the war, the Bureau of Entomology and Plant Quarantine began converting and readjusting its research program to meet needs made more imperative by war or peculiar to it. This revamping is a continuing process to keep pace with the modifications in military operations and agricultural requirements. Research has been aimed at immediate objectives, attention to the long-time aspects being reduced to that necessary to prevent large losses in lines of work which owe their value to continuity over a period of years. Similar adjustments have been made by other research agencies.

That research men have been able to furnish a prompt solution of many of the wartime problems presented to them has been due to the availability of a background of research information—the product of many years of painstaking work directed toward peacetime objectives. The value of careful basic work and its adaptability to new problems has been amply demonstrated.

Many technical advances have been made during the war, and during the period just preceding it, which are being utilized in medical entomology and in the protection of foods, fibers, and materials from insect attack to meet emergency conditions. Many of these will have a marked influence on the progress of entomological research and practice after the war is over. There is not time to attempt

any exhaustive review of these advances, or even to mention many of them. Some of the most striking, however, have been in medical entomology. They have been particularly interesting as demonstrating what can be done by intensive effort in fields that were believed to hold little prospect for extensive advances in techniques or methods. Certain of these developments hold promise of revolutionizing the control of typhus, malaria, and other insect-transmitted diseases. The Army and the Navy have been alert to the possibilities of new methods, many of which have been adopted into extensive practice with the consequent opportunity for observing their defects and of further improving them.

The adaptation of methyl bromide fumigation to the control of lice and the effective use of lousicides are examples of this progress. The improvement and extensive use of mosquito repellents and the development and utilization of aerosol "bombs" in local mosquito control are particularly noteworthy.

The shortage of insecticides due to the war has stimulated a search for new toxicants, new synergists, and other types of extenders, and has furthered the more economical use of critical insecticides through studies of reduced dosages and of diluents and other adjuvants. It has increased the investigation of new organic compounds and of organics, such as the thiocyanates, which are already commercially available. Certain of the new materials, revealed as a result of this intensive search, will undoubtedly take an important place in future insect-control recommendations. Many of these investigations are still in the preliminary stage. The new fumigant DD (dichloropropane-dichloropropylene mixture) and the insecticide DDT (dichloro-diphenyl-trichloroethane) are among materials which give encouragement that they will be of ultimate importance in the insect-control picture.

The adaptation of smokes as a means of distributing insecticides in the aerosol form, both for malarial control and for use against crop-infesting species of insects, holds great interest for the future. Even the use of explosive bombs for insecticide dissemination is suggested.

There has been extensive development of apparatus for the application of insecticides and for other purposes, which has added to the effectiveness of insecticides and other types of insect control. The increased use of airplanes, autogiros, or even helicopters is strongly indicated. High-powered, rough-usage equipment adaptable to insect surveys and control operations, such as suppression of grasshoppers and the Mormon cricket, has been devised for military uses. The development of special equipment to save labor has been encouraged by manpower shortages. For example, great improvement is being made in equipment for mixing and distributing grasshopper bait and for dispersing concentrated spray mixtures and dusts from the air. There is much to be done in perfecting various types of apparatus and adapting them to entomological control.

The shortage of seeds of many varieties which were formerly imported and the revised agricultural program in many areas have accelerated the study of insects affecting seed production and have centered attention on the importance of honeybees as pollinating agents.

The wartime emphasis on food production and the scarcity of manpower and insecticides for control of insect outbreaks led to the establishment of surveys in cooperation between the Bureau of Entomology and Plant Quarantine and various State agencies to keep a running account of the abundance of serious insect pests so that an intelligent distribution could be made of available insecticide supplies. Surveys especially designed to detect new insects which may gain entrance to our shores are being conducted so that prompt action may be taken to prevent their permanent establishment and the consequent loss to important food crops. These surveys have resulted in the extension of cooperative relations between State and Federal agencies, which have been extremely helpful in the present situation and which should be further nurtured. On the other hand, the regular pest survey has been inadequately supported.

With all the developments in the highly practical field, fundamental work, on which the future of the science rests, has languished. Many of the entomologists engaged in fundamental revisionary studies in taxonomy, for example, have switched their activities to fields more directly associated with practical aspects of the war or of agricultural production,

or have been so burdened by the volume of necessary determinations that little of the fundamental work has been accomplished. Physiologists and morphologists have transferred their energies to other fields or have redirected their activities to apply directly or indirectly to war demands.

The war has brought forcibly to our attention serious gaps in the accumulated knowledge of insects, of which we have been scarcely aware or which have seemed unimportant. For example, the extensive and elaborate malaria survey and control programs instituted by the military services have made demands upon insect taxonomists and biologists for information which they do not possess and which cannot be obtained promptly. Intelligent and effective field operations against malaria require definite and full knowledge of the vectors, but for various forms this is not immediately available. Nowhere are there adequate reference and research collections for a thorough, overall taxonomic study of anopheline mosquitoes; and biological data are scattered and fragmentary in many cases. Undoubtedly, one reason for our failure fully to meet the needs of war conditions is the provincial character of much of the work that has been done. This immediately suggests the need for future emphasis upon cooperative undertakings involving investigators throughout the world and covering the world insect fauna.

EFFECT OF THE WAR ON REGULATORY ENTOMOLOGY.—Quarantines, whether foreign or domestic, are sometimes considered as barriers to trade. That they may provide channels for trade through regulation and treatment of produce and materials which would otherwise be embargoed because of the hazards of pest introduction may be overlooked. The importance of this aspect of regulatory entomology has been particularly emphasized as a result of the great dislocation of normal trade by war.

Foreign plant quarantine enforcement had presented many troublesome ramifications, which at times have taxed the ingenuity of those charged with this responsibility. The disruption of normal traffic due to military requirements and the exigencies of war has caused emergencies which have required special handling on the spot to avoid interruption in the movement of essential materials and at the same time to protect American agriculture from unwelcome alien pests. Emergencies have necessitated the admission of certain products, particularly strategic materials, at ports of entry in areas where hosts of these pests are grown and the climatic conditions are favorable to their establishment. Vessels crippled by enemy action and carrying prohibited material have been forced to put in at United States ports and have required special attention to guard against pest risk.

Rapid expansion of air travel and the approval of additional airports of entry in widely separated areas in the United States, including Hawaii and Puerto Rico, present not only an ephemeral problem but one that will continue permanently after the war. The number of planes inspected in the fiscal year 1943 showed a 51-per cent increase over the previous year, and it is significant that 40 per cent of these planes carried restricted or prohibited plants and plant products, some of which were infested with injurious insects and plant diseases not known to occur in the mainland of the United States. The arrival of large quantities of parcel-post packages carrying prohibited or restricted plant materials, some of which have been found to be infested with injurious insects, presents a perplexing situation exceedingly difficult to overcome. Pest risk has been altered by changes in the source of certain products. Broomcorn, for example, which heretofore was imported through northern ports in considerable quantity from Hungary, is arriving at southern ports from Argentina. This change in the principal source of supply has altered the pest risk associated with such importations, so that we no longer have to deal with the well known European corn borer but with several species of *Diatraea*, some of which apparently do not occur in the United States. The need is increasing for new methods of treatment that will permit the entry of fruits and vegetables, some of which have been excluded for many years because of the pest risk involved, but which could find a favorable market in the United States during the off-season for similar domestic products.

The enforcement of Federal and State domestic quarantines has also been affected by unusual demands incident to

movement of war supplies. For example, the amount of lumber certified under the gypsy moth quarantine reached a new high for the fiscal year 1943. The great need for vegetables for supplying Army camps increased the quantity that had to be inspected and certified under the Japanese beetle quarantine. Much of this produce, instead of moving into the New York metropolitan area, as would be the case under normal conditions, moved outside the area infested by the Japanese beetle. More than 5600 loaded refrigerator cars were fumigated with methyl bromide or hydrocyanic acid gas during 1943. Research developed new schedules for fumigation to permit treatment under the special conditions of the new shipping demands. Modifications in procedures and equipment had to be established to conserve manpower.

EFFECT OF THE WAR ON PUBLIC-SUPPORTED CONTROL PROGRAMS.—Although handicapped by shortages in manpower, equipment, and materials, the large-scale control programs aimed at prevention of spread and suppression of insects, conducted cooperatively by Federal and State agencies, have been continued. Changes have been made in emphasis and, in some cases, in objective. Continuation of these programs has been possible only through the utilization of shortcuts and labor-saving procedures and devices. Large-scale control of grasshoppers, the Mormon cricket, and similar crop-destroying species has been of special importance as a means of conserving food and livestock feed under the present conditions of scarcity.

The difficulties in controlling large outbreaks at this time have encouraged emphasis on prevention in their incipiency. Control after an outbreak is under way is wasteful at best. It is expensive in men and materials, and is never so successful that there are not large crop losses in spite of it. The principle of prevention was applied on a large scale to grasshoppers in Yellowstone County, Mont., and in certain areas of California during the fall of 1943 through special fall roadside and breeding-ground control. Results are awaited with interest. Preventive programs are under consideration in Kansas, South Dakota, Wyoming, and other States for the coming season. Prevention is sound in principle. The interest in food protection and the national urgency for food production have given an opportunity to test its effectiveness and practicability on a large scale under several conditions and to determine its cost in men, equipment, and money.

EFFECT OF THE WAR ON EXTENSION ENTOMOLOGY.—The important role of extension entomologists in enlisting the cooperation of farmers in applying control principles developed by research was never more apparent than now. Although much publicity is given to large-scale control of outbreaks supported by goverment—Federal, State, or county—the the control practiced independently by individual farmers on their own farms contributes more, in its total effect, to the food supply of the Nation. Inclusion of insect control in a general extension program is not enough to obtain adequate acceptance of good control practices. The insect-control program must be organized and directed by men who know insects and who are, themselves, in touch with sources of research information. Standard control methods have required adaptation and modification almost overnight to conform to existing supply situations and to meet special problems arising from the modified agricultural program. They can be successful only through a continuous flow of information between the extension specialist and the research man. The extensive cattle grub control program, being conducted by many States as a means of providing increased beef and leather, is a good illustration of what can be accomplished by extension and research cooperation. It also affords an excellent example of the disruptive effect of changes in supplies of effective materials on control programs organized on an extension basis.

EFFECT OF THE WAR ON TRAINING OF ENTOMOLOGISTS.—Any discussion of the effect of war on entomology would be incomplete without reference to the education and training of entomologists. Academic training in entomological and similar technical fields is now at low ebb. Male enrollment in college courses in entomology is small, graduates and undergraduates are going into the armed forces and industry, and many of them may finally seek other fields of endeavor. Each year of the war fewer young academically trained men are available for replace-

ments. College and university staffs have felt the effects of the reduction in numbers of students and in many cases have shifted their activities to the teaching of subjects, only remotely connected with entomology, to military detachments requiring special courses. The loss entailed in this interruption in the training of competent entomologists will probably be felt more severely in years after the war than at present. There is danger of a serious hiatus in the succession of well-qualified, trained men to maintain adequate entomological research and other activities. These are difficulties which are inherent in the present situation. They are difficulties which must be accepted without complaint, but they also must receive the earnest attention of entomologists and educators looking forward to maintaining the high standard of work in entomology which we have learned to expect.

While the output of trained men from the colleges has almost ceased, there has been a greatly increased demand for qualified men in the Army, the Navy, and the Public Health Service. The Bureau of Entomology and Plant Quarantine alone has contributed nearly 160 trained men to these services.

PUBLIC KNOWLEDGE AND APPRECIATION OF ENTOMOLOGY INCREASED DURING THE WAR.—The Victory Garden program has given a wide appreciation of what insects can do to crops, to thousands of people who have had their first experience in attempting control, and who, even though city gardeners, have been convinced that insect control must be an important part of farming. The public has been informed in press stories and full-page advertisements of the value of mosquito control as a means of preventing malaria. Livestock and creamery associations have assisted in acquainting the segment of the public which they serve with the value of insect control. Cotton ginners, oil millers, and seed crushers have continued to tell the story of boll weevil control by stalk destruction, and the pink bollworm of cotton has been the target for a very effective publicity campaign, organized and financed by cotton producers, banks, and local business men, as well as the National Cotton Council. Railroad companies, grain-elevator companies and grain-dealer associations have aided in giving the public information on grasshopper control, though only indirectly interested, and have helped in other ways.

COOPERATION IN ATTACKING ENTOMOLOGICAL PROBLEMS STIMULATED BY THE WAR.—Beginning before the war and continuing with increased emphasis as men have become scarcer and problems more urgent, there has been widespread effort to develop the cooperative approach to entomological problems. As an illustration, little of the work of the Bureau of Entomology and Plant Quarantine is now conducted without direct cooperation with one or more State entomological agencies, and with workers in allied fields both within and without the Department of Agriculture. There has been a healthy development of joint projects with pathologists, agronomists, plant breeders, soil conservationists, chemists, and agricultural engineers. Except possibly a few who are living in the past, entomologists are concerning themselves with the solution of problems rather than with building barriers between entomologists and workers in allied sciences and between entomologists on State payrolls and entomologists in Federal employment. Special activities arising out of the war have called for an unusual degree of quite voluntary, informal cooperation. Among these may be mentioned the preparation of estimates on insecticide requirements and the insect-abundance surveys to give a basis for distribution of insecticide materials according to insect occurrence. The insecticide industry has cooperated in supplying information, normally considered confidential, on production and distribution and in other ways.

INTERNATIONAL CONSIDERATIONS STIMULATED BY THE WAR.—The United Nations Conference on Food and Agriculture, which met in May 1943, recognized the need for a great increase in the production of food if progress is to be made toward freedom from want. It declared: "There has never been enough food for the health of all people. This is justified neither by ignorance nor by the harshness of nature." After an exhaustive study of the factors affecting food production, it pointed out, as one of the important factors, that "Farming systems should be so designed . . . as to protect crops and livestock from major pests and diseases." It recommended that a program of research designed to meet the continuing problems of

agriculture within the various countries represented at the Conference should be adopted by each country. It further recommended that "spread of existing knowledge by education and the development of new knowledge by research should be constantly promoted and that in these matters nations can cooperate to great advantage." It declared that "freedom from want is difficult to achieve without concerted action among all like-minded nations to expand and improve production, to increase employment, to raise levels of consumption, and to establish greater freedom in international commerce."

Improvement of production and the establishment of freedom in international commerce have an important bearing on the development of entomology. It is indicated that production of food crops on the most economical and efficient basis must be considered from an international standpoint; that the effort, now directed toward producing foods to meet war demands, will continue in some form because of pressing civilian requirements after the war is over; and that barriers to international commerce will retard recovery and the future development of international well-being. The principles enunciated by this Conference emphasize the desirability of close international contact between scientists and free exchange of information and research results.

POSTWAR ENTOMOLOGY.—Postwar planning involves many factors beyond the knowledge of any individual, institution, agency, government, or country. It includes many imponderables, the weight of which will be determined by future events. Any detailed plan for action must inevitably be upset by facts not now known. However, because of the magnitude of the problem and the suddenness with which it will be confronted, the subject of postwar planning in entomology merits advance consideration by all entomologists, and particularly by those who have the responsibility for administering entomological activities and for directing and shaping their trend.

One of the first postwar tasks will be the readjustment of research, teaching, regulatory, and control programs to meet the new peacetime requirements. Readjustments will have to be made to reinstate entomologists who have returned from military assignments. Consideration must be given to the long view instead of the immediate future, to which we have recently been limiting our thought. International readjustments in commerce, transportation, and agricultural production will have to be studied and weighed as they affect the introduction, control, and domestic distribution of pests.

Research of great merit for the long pull, which has been interrupted or abandoned "for the duration," must be resumed. One of the important concerns of entomologists after the war should be the reestablishment and support of scientific research in such fields as insect biology, taxonomy, morphology, and physiology, as a basic necessity for sound practice in applied entomology. What may be accomplished will depend, however, on the extent to which the need for really basic knowledge is recognized. Both before and during the war much research as such has been discontinued, and trained scientists have been diverted to service activities of one kind or another. Readjustments to research may be difficult, and in any case they must await encouragement and support from public agencies.

The results of wartime research have great promise for application to the solution of peacetime problems. There must be a change in stress from military to civilian needs. For instance, insect repellents developed for military use may be of value in the protection of livestock and foods from insect attack and contamination as well as for the protection of man in peacetime pursuits. The pressure for information on certain problems will disappear when normal world trade is reestablished. For example, the same urgency will no longer exist for finding substitutes for such insecticides as pyrethrum and rotenone-bearing materials. Research, however, is so fundamental to the development and progress of all phases of applied entomology that it can hardly be discussed alone.

Disease problems will confront this and other countries of the world as a result of the return of troops from the far-flung war theatres and because of extensive postwar international adjustments. Probably the most serious of these are certain insect-borne diseases such as malaria, filariasis, typhus, yellow fever, plague, and leisht maniasis. This situation presents difficul-

entomological problems. The entomologist can contribute to their solution in cooperation with the physician and sanitarian.

The imagination and resourcefulness of the entomologist concerned with the investigation and control of anopheline mosquitoes is challenged by the advocacy by Dr. J. P. Mountin, of the United States Public Health Service, at a recent meeting of the National Malaria Society, of a plan to eradicate malaria from this country.

After the war, manpower shortages will be converted overnight into surpluses. Tens of millions of Americans and hundreds of millions in other countries now engaged directly or indirectly in military activities must be rehabilitated and reabsorbed into peacetime pursuits. The products of the world will be made available to the various peoples of the world in volumes and varieties not heretofore undertaken or deemed possible. The ocean-going merchant marines will be occupied in transporting foods, raw materials, and manufactured goods to rebuild a devastated world and to feed the starving people in the war-torn countries. Large numbers of skilled air pilots and tremendous numbers of transport planes will be available with the coming of peace. Plane-manufacturing facilities to meet the requirements of a peacetime air commerce will be abundant. The air age will have arrived, and commercial planes will ply the air in cobweb routes to the remote parts of all the earth. Airplanes will be engaged in transporting many of the products now carried by boat and train. Perishable foods, fruits, and vegetables not heretofore available for broad consumption will occupy space in the daily commerce of the world. The establishment and maintenance of trade balances, possibly through the extension of reciprocal trade agreements, will make the trade in certain commodities, bearing pest risk, of much greater importance than their total value and volume would imply.

Workers engaged in regulatory control of pests and their research associates must find ways to prevent the dissemination of plant pests with a minimum of interference with the movement of foods, products, and other things that carry these pests. The embargo approach of yesterday will be out tomorrow. This means a restudy and revamping of our quarantine structure and gives a high priority to research for the development of treatments through chemical, mechanical, or other devices whereby the pest can be separated from the carrier in international and interstate shipment of products.

Present and potential knowledge of agricultural pest control indicates the possibility of making many insect-pest carriers safe for transportation by treatment before movement, en route, or at destination, whichever may be most effective and convenient. New chemicals not yet available for general use are already known. Their practical application may permit great strides in this direction and help in solving the problem incident to expanding markets for foreign and domestic products. Undoubtedly other chemicals will be discovered in the future. Visual inspection as a basis for certification is slow, expensive, and inadequate at best. The development and application of adequate treatment methods would render products safe for free movement without further attention, inspection, certification, or regulation.

While the expanded trade in terms of variety of products will increase the need for greater freedom of movement, it will also increase the hazard of pest introduction. Postwar trade in products of forest, jungle, and mountainous interiors from foreign countries will open the way for the introduction of possible pests now known or unknown. Many of these which may not be of great importance in their native habitats could become serious menaces to domestic agriculture if introduced, as has been demonstrated by such pests as the Japanese beetle.

Within this country there may be comparable revolutionary changes in transportation procedures through the development of great air networks and the establishment of airports and terminals in cities not now important as transportation centers. Transportation time between cities will be reduced from days to hours and minutes. Consequently, the possibility of rapid dissemination of pests which may be introduced or are not now widely distributed within the country will be greatly increased. These changes in transportation methods may permit ships to load cargoes at inland river ports of foreign countries and discharge them at river and lake ports in the interior of the United States. Cargoes and passengers will be

picked up by plane at numerous interior points and foreign countries and discharged within a day's time at airports in the interior of this country. Because of the short duration of trips, the planes, as well as their cargoes, passengers, and crews will become of considerable importance as possible carriers of pests. There is the need for extensive planning for revisions of existing procedures in pest exclusion and prevention of spread to meet these new situations. Pest surveys throughout the country will need to be continued and greatly expanded to discover introduced pests before they have an opportunity to become established or widely disseminated.

Despite the success that may be attained in efforts to stop pests while allowing products to proceed to destination, the United States will be exposed to, and probably infested or infected by, newly introduced plant pests. Pest-control problems will increase in scope, intensity, and economic importance. They challenge the entomologist and plant pathologist, be they in the field of research, quarantine, or control. New approaches will have to be found and more effective attacks applied.

In the field of insecticide chemistry war is affording a stimulus to new discovery, to improvement of known materials, and to finding substitutes for conventionally standard remedies of the past. Some new chemicals and methods can now be used for war purposes only, but will be available for control of agricultural pests with the return of peace. New fumigants, contact insecticides, stomach poisons, and aerosols have been discovered which offer encouragement that improvement over old materials and procedures will be available for economic pest control. There will also be new physical adaptations and new applicators in the field. The combined knowledge of the chemist, the physicist, the engineer, the entomologist, and the mechanic will be required to appreciate and utilize them. In attempting to appraise the possibilities of newer materials, one might inquire whether aerosols offer the solution to the control of mosquitoes, greenhouse insects, the citrus whitefly, the gypsy moth, and others. Will cheap soil fumigation solve the Japanese beetle and white-fringed beetle problems, or will insecticides drilled in with fertilizer or seeds hold damage by soil forms to an economic minimum? Will the use of bacteria or fungi have a greater place in insect control, as is hinted by the success with milky disease for the Japanese beetle? This field has been hardly touched.

It can be assumed that great quantities of all manner of equipment will be available for adaptation to practical use in pest control—jeeps for scouting and surveying, heavy trucks to haul materials, boats for amphibious operations, light and heavy conventional planes, and helicopters to apply concentrates, dusts, and baits. While ground equipment will continue to have an extensive and important part in pest control, aircraft, whether publicly or privately owned, will play major roles in this field. Entomologists will need to gear their thinking of pest-control equipment to a higher level—from the hand distribution of grasshopper bait to the converted, four-motored bomber, and from the mule-back cotton duster to the aircraft duster. The more aggressive entry of engineers and trained mechanics into the investigation of field entomological equipment presages speedier progress and renders unnecessary the expenditure of valuable time of trained entomologists in a mechanical field, for which they are not adequately prepared.

The prevention of large-scale outbreaks of native or introduced pests should assume a more important place in the pest-control program than it now occupies. That such outbreaks of some insects can be prevented by appropriate and timely action has been amply demonstrated; it is probably equally true for others.

Intelligent direction of preventive action, as well as of individual or publicly supported control, requires constant information on insect abundance and distribution. The basic need for surveys to determine the extent and intensity of infestations by specific pests has been recognized, and such surveys have been generally utilized in connection with organized control programs. There has been cooperative reporting of insect occurrence in the Insect Pest Survey, and more recently in surveys organized in response to demands for insecticide conservation and increased production of food, feed, and fibers. The future should see the establishment of an adequate crop-pest-reporting services as a basis for the procurement and

distribution of materials and equipment, for advising individuals of control needs and for organizing control operations. A reporting system not unlike that now existing for the weather may not be a too fantastic thought.

Research on an international basis which will furnish information on insect pests wherever they occur—their distribution, host plants, and capacity for damaging economic crops—will be of increasing importance. International cooperation between entomologists and the establishment of full confidence among them, implemented by free and prompt exchange of factual data, are essential to crop-pest protection for the mutual benefit of all nations concerned.

It is recognized that this review of the effect of war on present and future entomological progress has been sketchy at best. Many of the topics mentioned will be discussed in greater detail during the proceedings of the next two days. These remarks have been aimed to direct attention to some of the major influences of war and may serve as a background for the papers and discussions which will follow. The conclusion that the problems in entomology will not be lessened after the war, but will be increasingly complicated and will assume greater international importance, would appear justified by the facts now available to us. They present a challenge to the wisdom and foresight of all of us.—12-7-43.

Biological Studies of Two Potato Flea Beetles in Eastern Washington[1]

E. W. JONES, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A study of two species of flea beetles attacking potato tubers on irrigated land in eastern Washington was conducted in 1940 in cooperation with the Washington Agricultural Experiment Station. The biological phase of the problem, including the abundance, habits, and ability of the two species to damage the tubers, was undertaken by the author.

The western potato flea beetle, *Epitrix subcrinita* (Lec.), has been common in both eastern and western Washington since 1913 (Yothers 1917). Although damage to foliage has occurred in eastern Washington, very little tuber injury has ever been observed from this species.

In 1932 Webster and coworkers (1932) reported injury to tubers in the Yakima Valley in eastern Washington, and since 1936 commercial damage has been reported in the Kittitas Valley. This injury has been attributed to the same species that was responsible for tuber injury elsewhere in the state and in 1932 was reported to be extending its range in western Washington, particularly in Grays Harbor and Pacific Counties. Webster (1932) referred to it as *Epitrix cucumeris* (Harr.), but recent taxonomic studies by L.G. Gentner, of the Southern Oregon Branch Experiment Station, have shown that it is different from the *E. cucumeris* found in the East. Until he describes it as being a different species, however, we shall continue to call it *E. cucumeris*.

REARING METHODS.—In laboratory rearing experiments the beetles were placed in small glass vials with potato leaves for food. The vials were inverted over wet blotters and the eggs deposited thereon. The eggs were held on moist blotters in salve tins throughout their incubation period. The newly hatched larvae were placed on slices of potato and held in salve tins for the duration of their developmental period. Rearing experiments were conducted at a temperature of about 70° F.

In the field experiments beetles were reared in metal cylinders 18 by 18 inches, which were pushed into the soil to a depth of 6 inches over potato plants and covered with cheesecloth. Each isolated plant was infested with a known number of beetles. Soil temperatures at a 3-inch depth averaged about 70° F. during the season. To obtain the immature stages, the soil in the cages was removed and washed through 24-, 40-, and 60-mesh screens and the residue examined by the flotation method. Large larvae, prepupae, pupae, and adults were taken on the 24-mesh

[1] This work was done under the direction of M. C. Lane, in charge of wireworm investigations in the Pacific Northwest, Walla Walla, Wash.

screen. Most of the larvae passed through the 24-mesh screen and were caught on the 40-mesh screen. Newly hatched larvae that went through the 40-mesh screen were caught on the 60-mesh screen. Soil washing injures the immature stages of flea beetles, and many of them do not survive, but adults are not injured.

LIFE HISTORY UNDER LABORATORY CONDITIONS.—Complete oviposition records were obtained for 12 *Epitrix cucumeris* females that had been reared in the laboratory. These adults deposited from 106 to 139 eggs each, or an average of 132, during periods ranging from 17 to 30 days. The majority of the eggs were laid within 10 days at 80° F. and within 20 days at 70°.

FIG. 1.—Mechanized rotary trap for sampling flight of flea beetles.

Oviposition records of *Epitrix subcrinita* were obtained with two large groups, one at 80° and the other at 70° F. The majority of the eggs were laid within 10 days. Individuals deposited from 4 to 14 eggs over periods of 25 to 30 days.

The developmental periods of both species under a constant laboratory temperature of 70° F. are summarized in table 1.

Table 1.—Length of developmental period of *Epitrix cucumeris* and *E. subcrinita* when reared in the laboratory at 70° F., Ellensburg, Wash., 1940.

	E. CUCUMERIS		E. SUBCRINITA	
PERIOD	Number	Mean Days	Number	Mean Days
Incubation	449	8.0	748	8.0
Larval	204	15.3	13	16.6
Prepupal	11	6.1	3	12.7
Pupal	11	8.2	3	9.0
Egg to Adult	126	40.7	10	49.2

LIFE HISTORY UNDER FIELD-CAGE CONDITIONS.—One hundred adults of *Epitrix subcrinita* were placed in each of 2 cages on July 17. When the first cage was examined 27 days later (August 13), 15 immature larvae were recovered. When the second cage was examined at the end of 50 days (September 5), 9 insects, consisting of 6 newly emerged adults, 1 pupa, and 2 larvae, were recovered.

Fifty adults of *Epitrix cucumeris* were placed in each of 3 cages on July 31. After 36 days (September 5), when the cages were examined, 73 insects, consisting of 16 newly transformed adults, 34 pupae, and 23 larvae, were recovered.

By comparison with table 1 it will be seen that with both species the time required to complete a life cycle in the field cages agreed well with that in the laboratory. The life cycle of *Epitrix subcrinita* appears to be longer than that of *E. cucumeris*.

Potato tubers in the *Epitrix subcrinita* cages showed no flea beetle injury. In the cages containing *E. cucumeris* 9 tubers showed 211 tunnels and 28 surface tracks made by the flea beetle larvae.

FLIGHT ACTIVITY.—To study the flight activity of the two flea beetles, a mechanized rotary trap (Fig. 1) was set up in a potato field 3 miles north of Ellensburg. This trap, a modification of that devised by Chamberlin & Lawson (1940), is equipped with two collecting nets made of wire screen mounted in such a way that they will rotate horizontally at heights of 2 and 6 feet, respectively. The trap was operated between the hours of 9 a.m. and 5 p.m. in the period July 10 to September 26. For comparison with the flea beetle populations in the field, collections were also made with a sweep net. Wind direction, air velocity, temperature, and relative humidity were recorded each day the trap was operated.

It was noted that very little flight occurred before noon, for about 17 times as many beetles were caught in the afternoon as in the forenoon. The beetles were taken in the trap on calm days only. The temperature and the intensity of light were of less importance than the wind. Beetles were flying on hot and cool days and on clear and cloudy days, but not when the wind velocity was over 7 miles per hour.

Epitrix subcrinita was taken on all days when weather conditions were favorable for flight, but *E. cucumeris* was not taken either by the trap or by sweeping in this field until July 28, and then the trap first showed the presence of this species.

The first-brood adults emerged, with consequent increase in the flea beetle population, the last week in July. Insecticide dust applied on July 31 practically eliminated the beetles until September. The second-brood adults emerged throughout September, and the trap collections were much larger the latter part of this month.

In a total of 64 beetles taken during the season in this trap, about 88 per cent were *Epitrix subcrinita*, and 76 per cent of the beetles of this species were caught in the lower net. Of 76 *E. cucumeris* beetles taken in the trap, 67 were caught in the lower net. Since the majority of the beetles fly at an elevation of 2 feet, their flights are probably from plant to plant rather than for long distances.

Table 2.—Sweep-net collections of *Epitrix subcrinita* and *E. cucumeris* in the Kittitas Valley, 1940.

Date	Fields	Flea Beetles Collected per 25 Sweeps	
		E. subcrinita	*E. cucumeris*
July 11–17	11	2.8	0.2
18–24	9	4.8	0.8
25–31	12	12.1	3.3
Aug. 1–7	8	14.5	5.3
8–14	7	5.3	1.4
15–21	16	2.8	1.9
22–28	12	8.8	4.7
Sept. 5–11	12	16.2	8.6
12–18	6	20.6	6.5
19–25	10	91.3	5.5

ABUNDANCE IN THE KITTITAS VALLEY.—Flea beetle populations in 22 fields in the Kittitas Valley from July to September were determined by means of net sweepings. Potato fields representing several soil types, having different degrees of slope, located in different parts of the valley, and surrounded by various types of vegetation, were selected for the counts. Four replicates of 25 consecutive sweeps were taken along the edge of each field on each sampling date. A total of 12,400 flea beetles were collected, of which 80 per cent were *Epitrix subcrinita*.

As shown in table 2, the adults of both species were most abundant the first week in August and the last of September. It was evident that these peaks coincided with the periods of emergence of adults of the first and second generations, although the populations during July and August were lower than normal because of the application of rotenone-cryolite dusts in June and July.

RELATION OF POPULATION TO NUMBER OF INJURIES.—The flea beetle tracks and tunnels on potato tubers were counted in samples obtained in September from the fields in the Kittitas Valley in which population counts had been made. These counts are summarized in table 3. The average number of beetles per 25 sweeps ranged from 46 to less than 1 for *Epitrix subcrinita*, and from 18 to less than 1 for *E. cucumeris*. Tubers were severely injured in September when the counts of *E. cucumeris* in July had averaged 16 to 18. In fields showing less than 5 *E. cucumeris* per 25 sweeps there was no commercial damage, the number of tunnels being less than 10 per tuber. Also in all fields with low populations of *E. cucumeris* but extremely high populations of *E. subcri-*

Table 3.—Relation of flea beetle populations on July 27 to potato tuber injury in September in 20 fields in the Kittitas Valley, 1940.

Adults per 25 Sweeps		Larval Tunnels per Tuber	Commercial Damage
E. subcrinita	*E. cucumeris*		
27	18.0	30 (10)[1]	Severe
4	16.0	21 (5)	Severe
2	10.0	13 (1)	Slight
4	2.0	10	None
1	0.2	9 (1)	Slight
5	0.5	—	Slight
1	0	8	None
35	0.5	7	None
14	0.5	7	None
30	4.0	5	None
9	0	3	None
46	1.3	2	None
2	0.2	2	None
15	1.0	1	None
9	0.2	1	None
6	2.0	1	None
10	.5	0	None
2	0	0	None
7	0.5	—	None
0.5	0	—	None

[1] Numbers in parentheses indicate scars or tracks on the surface of the tubers.

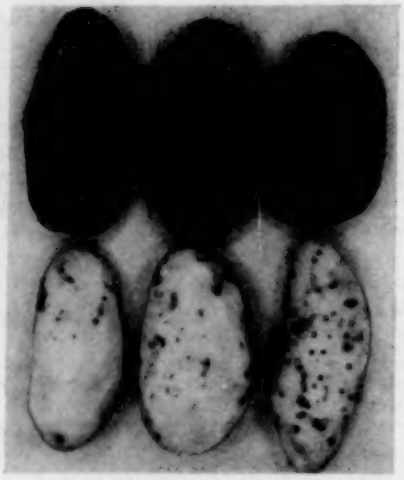

FIG. 2.—Damage to Netted Gem potatoes by larvae of *Epitrix cucumeris*, eastern Washington, 1940. Lower section after one paring had been removed.

nita, averaging from 15 to 45 per 25 sweeps, there was no commercial damage. These observations confirm the findings in the life-history studies, where the tubers in the cages containing *Epitrix subcrinita* showed no injury as compared with a large number of feeding tunnels on tubers in the *E. cucumeris* cages. There appears to be no relation between the *E. subcrinita* population and the number of injuries to potato tubers in fields containing both flea beetles. These studies indicate that *E. cucumeris* is the species chiefly responsible for injury to tubers.

OBSERVATIONS IN THE YAKIMA VALLEY.—Although the investigation in 1940 was conducted principally in the Kittitas Valley, a few observations were made in the Yakima Valley. At Benton City, Prosser, and Mabton no *Epitrix cucumeris* was found when samples were taken June 27, but *E. subcrinita* was fairly abundant, ranging from 10 to 25 beetles per 25 sweeps of the net. The early potatoes in these localities showed no tubers injuries, which further verified the absence of *E. cucumeris*.

Epitrix cucumeris was present on farms at South Satus. Adults were collected on June 27, July 18, August 2 and 27, and September 23. The largest numbers were obtained August 2 and September 23, about the time the first and second broods emerged. In one field from 61 to 73 adults per 25 sweeps were collected on these dates. In the same field severe tuber injury was observed on August 2 (fig. 2) on Netted Gem potatoes. Small populations of *E. subcrinita* were observed on the South Satus farms.

Epitrix cucumeris was taken in fairly large numbers on farms approximately 15 miles west of Toppenish. The first collections were made on June 3, and the others on July 18 and August 2 and 27, with the largest numbers, ranging from 10 to 15 per 25 sweeps, collected on July 18 and August 2. Tuber injury was severe on some of these farms. *E. subcrinita* was also fairly abundant in this area.

SUMMARY.—A study of two species of potato flea beetles, *Epitrix subcrinita* and *E. cucumeris*, was conducted in eastern Washington in 1940, with especial reference to their abundance, habits, and ability to damage potato tubers. Each species was reared in the laboratory and in outdoor cages and, although *E. subcrinita* required a little longer to complete development than did *E. cucumeris*, the developmental periods appeared to be similar. The former was much more abundant, but it was not observed to cause injury to potato tubers, whereas the latter caused severe damage. Flight habits were similar, both species being observed to fly rather close to the ground and only on calm days.—10-30-43.

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Control of the Tobacco Flea Beetle by Cultural Practices in Plant Beds

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For many years the tobacco flea beetle, *Epitrix parvula* (F.), has been recognized as a major pest of tobacco being grown for flue-curing. This insect may injure tobacco in one or in all of three periods in the development of the plant, namely, in the small-seedling stage in the plant bed, at the time of transplanting in the field, and during the development in the field, particularly at harvest time. Observations have shown that tobacco plants are especially susceptible to flea beetle injury during the period immediately following transplanting and up to the time when sufficient growth to support a relatively large population of beetles has been attained. Distribution studies by Levin (1940) have demonstrated that sudden influxes of large numbers of freshly emerged flea beetles into fields of recently transplanted tobacco occur each year soon after the plants have been infested by beetles that have emerged from hibernation. Inasmuch as tobacco plants are usually set in the field in the Oxford, N. C., area during the period May 9 to 25, and the emergence of the first or spring brood of flea beetles usually begins during the period May 25 to June 3, the influx of beetles may be expected from 1 to 3 weeks after transplanting. The same studies indicated that host plants such as tomato, potato, nightshade, and horse nettle were relatively unimportant, when compared with tobacco, as a source for the populations appearing in the fields of recently set tobacco.

Importance of Plant Bed as Source of Infestations.—The junior author, in his studies on the breeding hosts of the tobacco flea beetle, called attention to the importance of the tobacco plant bed as a source of infestations in the field. On the basis of the figures presented, a plant bed of 100 square yards can produce approximately 18,000 flea beetles during May, 208,000 during June, and 180,000 during July. These figures were obtained during a season when flea beetles were only moderately abundant and they do not indicate the maximum number of beetles that might develop in a plant bed of this size. Seasonal fluctuations in flea beetle abundance are noticeable and populations would be expected to vary above and below the figures quoted.

For many years farmers provided approximately 50 square yards of plant beds for each acre of tobacco set in the field. Since 1931, however, the blue mold disease, *Peronospora tabacina* Adam, has been a serious problem in production in plant beds throughout the Flue-cured Tobacco Belts, and the area of plant beds has been doubled, and even quadrupled in some cases, in order to assure an adequate supply of plants. The damage caused by blue mold varies from year to year, with the result that each farmer frequently has a large surplus of plants which he does not use.

To provide plant-bed sites where the soil is relatively free of disease organisms, farmers usually locate their beds in uncultivated areas, frequently near or adjacent to the tobacco fields. The sites of the beds are also changed to provide better physical and nutritional conditions of the soil and to obtain greater freedom from weeds, which ultimately seed themselves in old beds. This land is not used for other crops, so it is customary to abandon the beds after they have supplied the necessary plants. When the importance of these plant beds as a source of flea beetles is considered, in conjunction with the fact that there may be a large surplus of area as well as plants, their menace to the tobacco in the fields is easily recognized and the desirability of adequately disposing of them is evident. With this idea in mind, an experiment was planned and conducted during the seasons of 1940 and 1941 at Oxford, N. C., which was designed to compare the effectiveness of three simple cultural methods of disposing of plants in tobacco plant beds.

Description of Experiment.—The three cultural methods selected for comparison may be described as follows: (1)

[1] In cooperation with the North Carolina Department of Agriculture, the North Carolina Agricultural Experiment Station, and the Bureau of Plant Industry, *Soils and Agr. Engn., U.S.D.A.*

Pulling plants from the bed and scraping the soil to a depth of about 1 inch with a hoe, (2) plowing and harrowing, and (3) plowing. Tobacco plant beds were divided into plots 2 by 3 yards in size. Four such

FIG. 1.—Group of cages used to sample populations of emerging tobacco flea beetles in tobacco plant beds.

plots were provided for each of two replicates of the experiment in 1940 and five in 1941. As soon as the plants required for field use had been removed from the plots, three of them taken at random were subjected to the three cultural treatments, respectively, and the fourth was left undisturbed to be used as a check.

The efficiency of the cultural treatments in preventing the development of flea beetle larvae in the soil was measured by trapping the adult beetles as they emerged. This was accomplished by use of 5 circular, steel-framed, cloth-covered cages (Fig. 1) placed in each plot after treatment. Each cage covered an area of 1 square foot. The interior of each cage was thoroughly dusted with a mixture containing 1 per cent of rotenone, to kill any adult beetles that had been confined by the cages. At intervals of 2 days throughout a period of 30 days the cages were examined and the beetles were collected by means of a vacuum insect-collecting machine similar to that described by Hills (1933). The numbers of beetles thus collected were recorded.

Three distinct types of tobacco plant beds are utilized by farmers in the flue-cured tobacco area: (1) The open type, which is covered with the usual plant-bed cloth of at least 26 strands per inch but not enclosed with sidewalls. This type of bed offers very little obstruction to the entrance of flea beetles. (2) The pole type, which is fashioned with poles for side walls to which the cover is attached. This is probably the type of bed most commonly used and, as usually constructed, it only partially excludes the invading flea beetles. (3) The closed or "tight" type, which is enclosed with side walls made of boards to which the cover is attached. This type is coming into more general use and, if well made, is effective in excluding flea beetles. The plant beds used in 1940 were classed as the open type. In 1941 both the

Table 1.—The number of tobacco flea beetles developing in tobacco plant beds subjected to different cultural treatments, Oxford, N. C., 1940–41.

Treatments	Flea Beetles in 5 Sq. Ft. of Plant Bed in Replicate No.			Flea Beetles per Sq. Ft.	Control
	1	2	3		
					Per Cent
In open beds, 1940:					
Plants pulled and soil scraped	699	608	—	131	70
Plowed and harrowed	547	997	—	154	64
Plowed	1160	1311	—	247	43
Undisturbed (check)	1379	2947	—	433	—
In pole beds, 1941:					
Plants pulled and soil scraped	261	191	—	45	85
Plowed and harrowed	443	746	—	119	61
Plowed	1163	475	—	164	46
Undisturbed	1674	1361	—	304	—
In tight beds, 1941:					
Plants pulled and soil scraped	40	37	118	13	88
Plowed and harrowed	206	104	277	39	64
Plowed	227	231	304	51	53
Undisturbed	309	512	819	109	—

pole type and the closed type were utilized.

EXPERIMENTAL RESULTS.—The numbers of beetles that emerged in the cages during the emergence period are summarized in table 1. These data illustrate the value of pulling the plants and scraping the soil, as well as the value of using tight beds. Appropriate statistical analysis shows that, although plowing and harrowing is partially effective in reducing the numbers of beetles that emerged from the plant beds, it was not so effective as pulling the plants and scraping the soil. In small areas, such as are found in plant beds, the latter procedure is practical.

DISCUSSION OF RESULTS.—It is evident that the efficiency of any cultural method applied in tobacco plant beds for the purpose of eliminating them as breeding places for tobacco flea beetles depends on the degree of success attained in actually eliminating the plants. This is illustrated in the plots subjected to plowing alone, which destroyed fewer of the plants than did the other two methods. Even in the plots that were plowed and harrowed, occasional plants survived and furnished food for the development of a limited number of flea beetles.

Each tobacco farmer grows annually an average of 4 acres of tobacco for which he will utilize approximately 400 square yards of plant bed. The data presented in this paper show that this area of plant beds would produce, under the conditions of the experiment, from 392,000 to 1,559,000 flea beetles for the first brood alone, which would be from 18 to 71 beetles for each plant set out in the field. As there was a reduction from 70 to 88 per cent in the number of beetles that emerged from the plots in which the plants had been pulled and the soil scraped, it is evident that such a procedure would greatly reduce the possibility of flea beetle damage in a tobacco-growing area.

Sound agronomic principles would require that a soil-conserving crop be planted on any plant-bed site located on cultivated land. This may be done to advantage, provided the crop is not one of the few host plants of the beetle.

COST OF TREATMENT.—The cost of the destruction of tobacco plant beds by any of the three methods considered is not excessive. The tobacco grower at present has only 3 to 5 acres of tobacco planted from 300 to 500 square yards of plant bed. One man should be able to pull the plants and scrape the soil in 500 square yards of plant bed in a single day; and the other methods, such as plowing and harrowing, or plowing, would be even less expensive.

SUMMARY.—Tobacco plant beds have been shown to be prolific sources of flea beetle populations in areas devoted to the growing of tobacco for flue-curing. After the crop has been transplanted the plant beds continue to furnish large numbers of flea beetles throughout the season. Unless destroyed, these beds are a menace in the area.

Three methods of disposing of tobacco plant beds were tried: (1) Pulling the plants and scraping the surface of the soil with a hoe, (2) plowing and harrowing, and (3) plowing. It was demonstrated that any one of these methods resulted in an appreciable reduction in the potential flea beetle population developing in the beds. Pulling and scraping and plowing and harrowing were more effective than plowing only.—11-1-43.

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E. O. HAMSTEAD

Mr. Hamstead, of Kearneysville, W. Va., is now in training at the United States Naval Training Station, Farragut, Idaho. He states that he has, so far, been entirely free from any symptoms of seasickness but that notable insect life is mostly confined to the indoor varieties.

Selection of Soil Entrance and Oviposition Sites by June Beetles[1]

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Choice of sites for soil entrance and oviposition of at least some species of June beetles[2] appears to be strongly influenced by the physical characteristics of the ground cover. The presence of living plants of certain species seems to be much less important. Information pertaining to selection of such sites was obtained during field and insectary work conducted at the Arkansas Agricultural Experiment Station, Fayetteville, Arkansas, during 1943.

A relationship of the physical nature of ground cover to soil entrance is suggested by the frequent utilization by June beetles of plant debris as a daytime hiding place. A striking example of this habit was provided by *Phyllophaga tristis* during late April and early May of 1943. At this time is was found that the best method of collecting adults of the species consisted in scratching about in piles of dead oak leaves, particularly those directly under the trees. The beetles were generally found on the soil surface, although in deeper piles they were found mingled with the leaves and in a few cases had dug into the soil under the leaves. Prolonged dry weather had caused the clay soil to becom so hard that the beetles apparently found digging difficult. With the exception of a single case, however, all observed entrances into soil occurred under leaves at points where the soil was moister and therefore softer than that surrounding. Since many of the leaves naturally collected in depressions in the soil, it was not infrequent that limited patches of moist soil were found beneath them.

Phyllophaga fervida and *P. crassissima* were collected subsequently in similar accumulations of debris about their food plants. Dr. M. W. Sanderson, in unpublished notes, also records collection in Arkansas of several additional species under debris near food plants, and mentions seeing beetles crawl under such material when leaving trees in the early morning.

In order to clarify several basic questions regarding June beetle entrance and oviposition suggested by these observations, *Phyllophaga fervida* and *P. crassissima* were subjected to controlled conditions in the insectary. The first experiment was conducted to determine the effect of plant species and soil type on choice of a site. For this purpose a number of plants including species presumably susceptible and species presumably resistant to grub injury were each grown in ten different soils in an outdoor screen cage infested with fifty males and fifty females of *P. fervida*. The cage measured five feet square and five feet high, and was provided with a fibre-board floor in which 100 closely-spaced circular holes 3.5 inches in diameter had been cut. Jelly glasses in which the plants were grown were sunk through these holes into the soil until the tops of the glasses were flush with the level of the cage floor. Leaves of host plants were suspended from the top of the cage as food for the beetles. The plants were watered rather heavily each day in as uniform a manner as possible so that the ease of penetration of each soil would be similar. The beetles were collected in the field and placed in the cage on April 24; the last of them died about May 12. The glasses were then removed and the soil examined for eggs.

The plants used in the experiment were grown from seed with the exception of bluegrass and Bermuda grass which were started from individual shoots taken from sod, and were all started in a greenhouse before being moved to the outside cage. Partly because of this fact normal growth was never made; maximum height ranged from three inches for hop clover to eight inches for corn. Such plants might not be fully representative of field grown plants of the respective species as regards any attraction for June beetles. It is nevertheless probable that differential attraction due to plant species as such would be indicated since a relatively large number of species were available.

The 10 soils were taken from various localities near Fayetteville and varied widely in texture and natural white grub

[1] Research paper No. 765, Journal series, University of Arkansas.

[2] The species discussed in this paper are *Phyllophaga tristis* Fabr., *P. fervida* Fabr., *P. crassissima* Blanch.

population. In the experiment each plant and each soil appeared 10 times, making a total of 100 different plant-soil combinations. A 10 by 10 latin square was used for the plant arrangement, restricted to an extent allowing for good distribution of the soils.

The total egg deposition as affected by plant species was as follows: check (no plants) 0; timothy, 29; Bermuda grass, 24; bluegrass, 10; hop clover, 18; lespedeza, 28; oats, 24; wheat, 30; corn, (1 stalk per pot) 23; corn, (8 stalks per pot) 49. (Each figure represents oviposition in the 10 different soils.)

These data indicate that under conditions of the experiment there were no distinct preferences among the plant species involved. The number of eggs found in corn planted at the rate of eight stalks per glass, however, was more than double that in corn planted at the rate of one stalk per glass. This is an indication that density of top and root growth is a factor in entrance and oviposition. The ranking of all plant species grown, in fact, coincided more closely with density of combined top and root growth of these particular plants than with the severity of infestation which would be expected in the field.

It was apparent that there was little if any real difference in oviposition between the soils under the conditions of uniform ease of penetration maintained in the experiment, other than a lack of oviposition in sand and gravel. Gravel undoubtedly was completely unsuitable. The sand may have maintained a hard packed surface as a result of the frequent watering; such a condition probably would discourage entrance. The number of eggs deposited, disregarding sand and gravel, ranged from 21 to 42. There was no consistent correlation with degree of field infestation.

Observations were then made on *Phyllophaga fervida* and *P. crassissima* to determine whether choice of a site for entrance and oviposition, soil conditions being uniform was merely response to the mechanical condition of thick cover or was connected with suitability of the cover for adult or larval food. The choice offered the beetles was between soil containing growing wheat plants and bare soil covered with partly-rotted wheat straw. The straw was chosen as representing a material which would effectually cover the soil but would not attract the beetles by reason of providing suitable food either for adults or grubs.

In this work, again conducted on the outside, the cage was similar to the one previously described except that it was much smaller, accommodating only four jelly glasses. Four choices of entrance were given the beetles: (1) bare soil; (2) bare soil covered thickly with partly-rotted straw; (3) wheat plants about six inches tall 15 to 20 plants per glass; and (4) wheat as in number 3 but covered in addition with straw. In this last treatment the straw was worked down between the plants so that it covered the soil surface as completely as possible; this probably nullified any physical effect which the wheat plants may have had on the aboveground cover since the straw made by far the denser covering. The plants were grown outside the cage in jelly glasses buried to their depth in soil. Glasses containing no plants were treated exactly as were the others. Each set of glasses representing the four treatments was left in the cage exposed to the beetles one day only; new glasses were placed in the cage each evening at which time the previous set was examined for beetles and eggs. These examinations were made just before the beetles emerged each evening so as to minimize disturbance of normal habits of entrance and oviposition. Ten females were maintained in each cage along with two or three males. Due to deaths, however, and to the fact that some of the beetles remained in the straw rather than entering the soil, the number of effective females varied considerably. Entrance records included only those beetles found in the soil. Watering was done as uniformly as possible. Leaves of adult host plants were kept in the cage as food, always being placed against the side of the cage in such a way as to provide no cover for any treatment. Some feeding also occurred on the growing wheat. Data were obtained from one cage of *Phyllophaga fervida* during the period from May 24 to June 12 inclusive. A three-cage experiment using *P. crassissima* was conducted from June 18 to July 11, inclusive.

It was evident during these observations that both species preferred soil with some type of cover, and that straw met this requirement better than did wheat plants as grown in these experiments.

Phyllophaga fervida entered only where straw was present, and in about equal numbers regardless of whether the soil beneath the straw was bare or contained growing wheat plants. There were no entrances by this species in either bare soil or soil containing wheat plants where these were not covered with straw.

Entrances recorded for *Phyllophaga crassissima* were as follows: bare soil, 50; bare soil covered with straw, 90; soil containing growing wheat, 55; growing wheat covered with straw, 82. Again the more important attractive factor seemed to be straw, regardless of whether the soil contained growing plants or not.

The rate of oviposition by *Phyllophaga crassissima* apparently was increased by the presence of wheat roots in the soil. The number of eggs per beetle per day for those entering bare soil not covered with straw was .06, while in wheat plantings not covered with straw the number was .78. In bare soil covered with straw the rate was .27 eggs per beetle per day and in wheat plantings covered with straw it was 1.78 eggs. *P. fervida* oviposited about equally well regardless of the presence or absence of wheat. The rates were 2.90 for straw-covered bare soil and 3.07 for wheat plants with straw cover.

There was also an indication that straw cover in some manner increased the rate of oviposition of *Phyllophaga crassissima*. When straw was added to bare soil the rate rose from .06 to .27 eggs per beetle per day. When straw was added to wheat the rate rose from .78 to 1.78 eggs per beetle per day. Choice of sites by males was similar to that of females.

A distinct difference between *Phyllophaga fervida* and *P. crassissima* in entrance habits was noted. The foregoing data on the two species can be contrasted only with reservation since the two experiments were conducted at different times, weather conditions differed considerably, and the soil was kept more loose during the major part of the *P. crassissima* experiment. Nevertheless, the consistent refusal of *P. fervida* to enter soil not densely covered must represent a real characteristic of this species. Such a conclusion is further strengthened by other observations; in a cage used for another experiment with *P. fervida*, for instance, a mass of leaves placed in the cage as food accidentally fell upon a thin stand of bluegrass which ordinarily was rarely entered by the beetles. In this case the beetles crowded into the soil under the leaves in such numbers as to force one another out. Such a habit under field conditions seemingly would severely restrict the habitat of the species. Species with more generalized habits similar to those of *P. crassissima* in these experiments might be expected to infest a wider range of environments.

It may be possible to apply knowledge of June beetle behavior obtained in these experiments to the explanation or prediction of initial field infestations insofar as vegetative cover is concerned. The importance of this factor undoubtedly will vary greatly with soil conditions.

SUMMARY.—Factors influencing choice by June beetles of sites for soil entrance and oviposition were studied under cage conditions after noting that beetles in the field frequently use debris near food plants as a daytime hiding place. In one experiment there was no apparent choice between plant species by *Phyllophaga fervida* as measured by total oviposition. There was some indication that thicker stands of plants were preferred. Little difference in oviposition was noted in a wide selection of soils under uniform moisture conditions such as were maintained. Other experiments indicated that soil covered with partly-rotted wheat straw was more attractive to *Phyllophaga fervida* and *Phyllophaga crassissima* as a place of entrance than soil with growing wheat seedlings. The presence of wheat roots in the soil apparently stimulated oviposition by *Phyllophaga crassissima*.—11-18-43.

Jack D. Jones, a prospective member of the Association, is a Captain in the Field Artillery and is now stationed at Camp Tyson, Tennessee, attached to the headquarters of the Eleventh Army Corps Area. Captain Jones hopes to keep in touch with entomology, partly through the JOURNAL and other periodicals which, he states, are received regularly.

Reduced Dosages of Calcium Arsenate and Cryolite for Control of the Boll Weevil and Their Effect on the Cotton Aphid

L. C. FIFE,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[2]

Owing to the possibility that arsenicals may become scarce as a result of demands for materials needed in war industries, tests were conducted near Brownsville, Tex., in 1942 to determine the effect of reduced dosages of calcium arsenate and cryolite on the control of the boll weevil, *Anthonomus grandis* Boh., and their effect on the cotton aphid, *Aphis gossypii* Glov.

PLOT ARRANGEMENTS AND TREATMENTS.—Two series of field-plot tests were conducted, each series consisting of 4 replicated randomized blocks. In the first series 8 treatments were assigned at random to the 8 plots of a block. In the second series 5 treatments were similarly assigned. In series 1 each plot was 0.10-acre in size and contained 20 rows, whereas in series 2 each plot was 0.05-acre in size and contained 10 rows. In series 2 a buffer area of 10 rows (30 feet) at the sides and of 50 feet at the ends was left between plots.

The purpose of the experiment was to compare the effectiveness of undiluted calcium arsenate and undiluted cryolite with that of mixtures of calcium arsenate, cryolite, and basic copper arsenate with sulfur. Chemical analyses of the insecticides were made by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine. The calcium arsenate used was of a commercial brand containing from 2.2 to 4.3 per cent of water-soluble arsenic pentoxide by the Geneva method and 40 per cent of total arsenic pentoxide. The cryolite used was a synthetic material containing approximately 86 per cent of sodium fluoaluminate. The sulfur used was a 325-mesh conditioned dusting sulfur, containing 94.4 per cent of sulfur and 5.4 per cent of nonvolatile matter.

Eight effective applications of each insecticide were made in each series. Two other applications that were washed off by rain within 24 hours in series 1 were not considered effective. The applications were made at intervals of about 5 days, from July 3 to August 12 in series 1 and from July 20 to August 27 in series 2. Single-nozzle rotary hand dust guns were used for applying the insecticides. All dust applications were made early in the morning when the cotton was usually damp or wet with dew and the air for the most part was calm.

All the check plots in series 1 were dusted on July 31 and August 5 with a mixture of paris green (14 per cent) and lime (86 per cent) at the rate of 12 pounds per acre to control the cotton leafworm, *Alabama argillacea* (Hbn.). In series 2 all the plots and also the buffer area were dusted for leafworms on July 25 and again on August 1 with the paris green and lime. These applications no doubt helped to some extent in controlling the boll weevil and possibly other injurious cotton insects.

FIELD CONDITIONS.—The tests were conducted in two different fields planted about 1 month later than the average. The fields were fairly uniform, with approximately 15,000 plants per acre, and the soil was heavy black loam. A general migration of boll weevils started about July 15, especially from the early- to the late-planted fields. After this date the boll weevil infestations rapidly increased in all plots and remained high throughout the remainder of the season. Since the first application of dust was on July 3 in series 1 and on July 20 in series 2, all plots were exposed to a continuous influx of weevils for the greater part of both experiments.

Frequent rains during July and August were also an important factor in reducing the effectiveness of the treatments, because most of the dust was usually washed off within 2 or 3 days. In July there were 13 days with at least a trace of rainfall, in August 17 days, and in September 16 days, with totals of 0.62, 2.64, and 2.46 inches of rainfall per month, respectively.

RECORDS.—Infestation records for aphids and the boll weevil were begun soon after the first insecticide application and were continued at intervals of about a

[1] The author was assisted in the field by R. E. Schendel and G. L. McGonigle.

[2] In cooperation with the Texas Agricultural Experiment Station.

week until all applications had been completed. The aphid-infestation records were obtained by counting the aphids per square inch on 100 square inches of leaf area per plot at each inspection. The area near the base of the fourth leaf from the top of the plant was used for making the counts. The infestation records for the boll weevil were made by examining for feeding and egg punctures 100 squares per plot at each inspection. Five or six counts

Table 1.—Average boll weevil infestation, aphid population, and yield of seed cotton on four plots following various insecticide treatments for the control of the boll weevil and the cotton aphid at Brownsville, Texas, in 1942.

Treatment	Dosage	Aphids per Sq. In. of Leaf		Boll Weevil Infestation	Seed Cotton	Gain
	Pounds per Acre	*Max.*	*Aver.*	*Per Cent*	*Pounds per Acre*	*Pounds per Acre*
Series 1:						
Calcium arsenate	7.4	0.55	0.44	37	1670	716
Calcium arsenate plus:						
Sulfur 1:2	11.6	0.56	0.24	42	1568	614
Sulfur 1:3	13.6	0.40	0.20	47	1504	550
Sulfur 1:5	12.5	0.40	0.19	45	1402	448
Cryolite	6.0	0.33	0.15	44	1210	256
Cryolite plus:						
Sulfur 1:2	11.5	0.25	0.13	50	1156	202
Sulfur 1:3	11.9	0.35	0.11	47	1352	398
Check		0.33	0.10	50	954	
Minimum significant difference, 5 per cent level			0.10	6.7	307	
Series 2:						
Calcium arsenate	6.8	2.04	0.93	53	747	440
Calcium arsenate	8.1	2.14	0.86	61	705	398
Calcium arsenate plus:						
Sulfur 1:1	7.7	1.90	0.68	62	570	263
Basic copper arsenate plus:						
Sulfur 1:1	9.0	1.90	0.77	68	505	198
Check		1.12	0.42	69	307	
Minimum significant difference, 5 per cent level				7.4	216	

of boll weevils and aphids were made. The yield in seed cotton per acre was recorded for each plot, using 0.05 acre as the picking area per plot in each series.

SUMMARY OF RESULTS.—The insecticides used, the number of pounds applied per acre, boll weevil and cotton aphid infestation records, and the yield of seed cotton per acre are summarized in table 1.

In series 1 significant increases in the yield of seed cotton over the check were obtained from those plots treated with calcium arsenate and with mixtures of calcium arsenate and sulfur. Although there was a consistent decrease in yield as the ratio of sulfur increased from 1:2 to 1:5 in the calcium arsenate-sulfur mixtures none of the differences were statistically significant. The yields from plots treated with cryolite or cryolite-sulfur mixtures were greater than the yield of the check; however, only one increase could be regarded as significant: In series 2 the yields from plots treated with calcium arsenate alone and with a mixture containing equal amounts of calcium arsenate and sulfur were significantly better than the yield of the check.

It is doubtful whether the sulfur should be considered inert as it is somewhat effective against other insects such as pentatomids and mirids. A mirid, *Creontiades signatus* (Dist.), was rather abundant during June and July in several of the plots in series 1 ard is believed to have

caused considerable damage to squares and small bolls. No records were made of its population density in the various plots but it is likely that a considerable part of the gain from some of the treatments was due to the control of this insect.

The yields were increased by treatments of cryolite and the 1:2 cryolite-sulfur mixture and significantly so by the 1:3 cryolite-sulfur mixture. Treatment with the 1:1 mixture of basic copper arsenate and sulfur resulted in less increase in yield than treatment with calcium arsenate or the 1:1 calcium arsenate-sulfur mixture.

The maximum difference between comparable average seasonal boll weevil infestations was 16 per cent. Only plots treated with calcium arsenate and with the 1:2 mixture of calcium arsenate and sulfur showed significant reductions in weevil infestation.

Aphids never became abundant enough in any of the treated plots to cause appreciable damage, the maximum infestation being 2.14 aphids per square inch of leaf surface. With the exception of the plots treated with the 1:5 mixture of calcium arsenate and sulfur, dusting with calcium arsenate or calcium arsenate-sulfur mixtures caused significant increases in the aphid population in series 1. Applications of cryolite and the cryolite-sulfur mixtures were not followed by significant increases in the populations of the aphids. —9-28-43.

Summer Infestation of Farm-Stored Grain by Migrating Insects

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Migrating insects constitute an important source of infestation for wheat stored on the farm. As a part of the research work on the care of wheat stored in farm-type bins, conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Agricultural Marketing Administration, and the Kansas State Agricultural Experiment Station, a study was made of the flight of stored-grain insect pests in the vicinity of bins of wheat, their migration into the bins by flight or by crawling, and the seasonal abundance of these insects.[1]

The study was conducted during 1941 and 1942 at the experimental wheat-storage site established at Hutchinson, Kans., by the Commodity Credit Corporation of the United States Department of Agriculture. The site contained approximately 190 bins varying in capacity from 1000 to 5000 bushels. Possible sources of insect infestation were the wheat stored in the bins on the site, a country elevator located within a few hundred yards of east side of the site, and surrounding farm land.

[1] For descriptions of the species mentioned herein and their habits and importance, see U. S. Dept. Agr. Farmers' Bulletin 1260, Stored-Grain Pests, and U. S. Dept. Agr. Miscellaneous Publication 258, Annotated List of the Insects and Mites Associated with Stored Grain and Cereal Products, and of their Arthropod Parasites and Predators.

Three methods of trapping insects were used in the study, viz., flight screens coated with tanglefoot erected on the four sides bounding the bin site, a revolving trap erected and operated in an open space among the bins and near the center of the bin site, and ventilator traps fitted into the ventilators of several bins.

FLIGHT SCREENS.—Four screens of metal cloth, each 3 feet square, were mounted on 2 by 4-inch supports and mounted vertically 4 feet above ground level. One screen was placed on each side of the bin site. The screens were coated on both sides with tanglefoot to catch and hold any insects flying into them. They were put into operation during the first week of July 1942, and the insect pests of stored grain caught on them were removed at frequent intervals. A record was kept of the kinds and numbers trapped on each side of the screens. Data regarding the stored-grain insects caught on the four screens during July are recorded in table 1. It will be noted that five different species of grain-infesting insects were taken during the month, the most abundant being the flat grain beetle, *Laemophloeus minutus* (Oliv.), and the hairy fungus beetle, *Typhaea stercorea* (L.). Insects were caught in greater abundance on the sides

of the screens that faced away from the bins and on the screens located on the north side of the bin site than elsewhere.

REVOLVING INSECT TRAP.—An indication of the seasonal abundance of stored-grain insects in flight in the vicinity of the bins was obtained by means of a trap consisting essentially of two screen-wire nets mounted at the ends of 6-foot metal arms, which extended outward horizontally from a vertical shaft driven by an electric motor. When in operation the nets revolved at a rate of about 50 r. p. m., one about 3 feet and the other 6 feet above the ground. The nets were cone-shaped, with cloth sacks attached to the small ends. Insects caught in the nets were carried back into the cloth sacks and retained there while the trap was in operation.

The revolving trap, which was erected in an open space between the bins near the center of the bin site, was placed in operation on April 1, 1942, and was run intermittently throughout the season until October of the same year. Catches were examined at least twice daily during a 24-hour period of operation in order that the period of the day during which flight occurred might be studied.

The first insect pest of stored grain, a red flour beetle, *Tribolium castaneum* (Hbst.), was captured on May 26. A single rice weevil, *Sitophilus oryza* (L.), was caught on June 11 and a lesser grain borer, *Rhizopertha dominica* (F.), on June 12. Aside from these few specimens no insect pests of stored grain were caught in the trap until the first week in July. As indicated by the numbers of insects caught in the trap, grain-infesting insects were in heavy flight from the beginning of the second week in July to the end of the first week in September. The heaviest flight occurred between 6 p.m. and dusk. In hot summer days few insects were in flight during the day, although in periods of more moderate weather insects were caught during the cooler hours. The average catch per hour during the period 7 a.m. to 5 p.m. was 2 insects, the maximum being 12 and the minimum 0.3. During the period 5 p.m. to 7 a.m. the average catch per hour was 39, with a maximum of 89 and a minimum of 1.2. The maximum hourly daytime catch was recorded during the week of September 16, whereas the maximum hourly catch at night occurred during the period September 2 to 8. Approximately 45 per cent of the insects were trapped in the net operated at a height of 3 feet above the ground and the remaining 55 per cent in the net operated at 6 feet above the ground.

Table 1.—Record of stored-grain insects caught during July 1942 on flight screens coated with tanglefoot erected on each boundary of the experimental wheat-storage site at Hutchinson, Kans.

Location of Flight Screen on Bin Site	Number and Kind of Insects Trapped					Total Insects Caught
	Flat grain beetle	Hairy fungus beetle	Foreign grain beetle	Rice weevil	Lesser grain borer	
On side of screens facing the bins						
North boundary	5	19	0	0	0	24
East boundary	2	15	5	0	0	22
South boundary	52	31	8	0	0	91
West boundary	9	15	4	0	0	28
Total	68	80	17	0	0	165
On side of screens facing away from bins						
North boundary	140	152	22	0	0	314
East boundary	5	28	6	0	0	39
South boundary	54	20	8	0	0	82
West boundary	64	36	10	2	1	113
Total	263	236	46	2	1	548

A record of the grain-infesting insects caught by the trap during the 391 hours of operation between July 1 and September 22, inclusive, is given in table 2.

BIN TRAPS.—To determine just what species of insects actually entered the grain bins during the season, ventilator traps were placed in two 1,000-bushel steel bins that were tightly caulked so that the only avenue by which insects could gain entrance was through the ventilator opening at the apex of the roof. The traps consisted of galvanized sheet-metal cones

Table 2.—Weekly totals of species of stored-grain insects caught in the revolving trap, at Hutchinson, Kans., July 1 to September 22, 1942.

Period	Number of Insects Trapped									Number of Hours Trap Was Operated
	Flat grain beetle	Foreign grain beetle	Hairy fungus beetle	Lesser grain borer	Rice weevil	Red flour beetle	Square-necked grain beetle[1]	Long-headed flour beetle[2]	Total	
July 1–7	44	19	15		1				79	33
8–14	301	130	1,622	5	1	3	1		2,063	76
15–21	263	70	562	2		1	2	1	901	38
22–28	174	390	347	4	3		6		924	38
July 29 to Aug. 4	356	320	658	15	1	1	1	4	1,355	53
Aug. 5–11	200	823	883	1					1,907	22
12–18	203	251	976	1	1				1,432	38
19–25				Not operated						
Aug. 26 to Sept. 1	6	2		3	1				12	8
Sept. 2–8	414	674	212	37	1				1,338	15
9–15	115	30	91	95					331	61
16–22	14			93					107	9
Totals	2,090	2,709	5,366	256	9	5	9	5	10,449	

[1] *Silvanus gemellatus* Duv. [2] *Latheticus oryzae* Waterh.

terminating in quart jars. The cones were fitted tightly into the ventilator openings in such a manner that insects were unable to enter the bins without falling into the traps. The metal cones had a slant height of 20 inches and a large diameter of 14 inches. Metal jar lids with the tops punched out were soldered to the smaller and lower ends of the cones so that the quart jars could be unscrewed and replaced as desired. At times the jars were replaced by cloth sacks so that moisture entering the trap would soak through the cloth before it could ruin the catch. A small quantity of screened and insect-free wheat was kept in the bottom of each trap.

During September 1941 ventilator traps were in operation in two bins of wheat, one containing wheat having 13 per cent of moisture and the other wheat having 11 per cent of moisture. During the month some 1333 stored-grain insects were captured by the trap placed in the bin containing the wheat having 13 per cent of moisture. Of the five species of grain-infesting insects represented in the catch, the foreign grain beetle, *Ashasverus advena* (Waltl), was the must abundant, followed in order by the flat grain beetle and the hairy fungus beetle. Of the insects other than grain-infesting insects captured in the trap, there were 5000 wingless psocids or booklice. Also represented were numerous parasites of grain-infesting insects, including the species *Aplastomorpha calandrae* (How.), *Cephalonomia tarsalis* (Ashm.), *C. waterstoni* Gahan, *Chaetospila elegans* Westwood, *Eurytoma neomexicana* Gir., *Microbracon hebetor* (Say), and *Plastonoxus* sp. A record of the insects caught during September in this trap is given in table 3.

Table 3.—Weekly catch of stored-grain insects in bin ventilator trap, located in a bin with wheat having 13 per cent of moisture, September 1941.

Period	Number of Insects Trapped					Total for the Week
	Foreign grain beetle	Flat grain beetle	Lesser grain borer	Hairy fungus beetle	Indian-meal moth	
September 2–8	246	356	25	233	4	864
9–15	121	28	2	1	14	166
16–22	153	86	40	1		280
23–30	9	5	9			23
Total	529	475	76	235	18	1,333

During 1942 two bin ventilator traps were operated continuously from April 2 until November 1, examinations of the catch being made daily. One trap was placed in a bin located near the southwest corner of the bin site, while the other was placed in a bin located near the northeast corner of the site. Both bins contained wheat of approximately 11 per cent moisture content.

Booklice were first taken in the traps on April 6 and grain mites on April 10. During the entire season more than 35,000 booklice were trapped. Of the economic

Table 4.—Catches of stored-grain insects during 1942 in two ventilator traps in bins containing wheat having 11 per cent of moisture.

Period	Number of Insects Trapped[1]					
	Flat grain beetle	Foreign beetle	Lesser grain borer	Hairy fungus beetle	Rice weevil	Total
April 17	1					1
27	1					1
May 13–15			1			3
29	1					1
June 3–9	4		2			6
10–16		1	2			4
17–23		1				1
24–30	12			3		15
July 1–7	35		1	1	5	42
8–14	104	8	1	1		116
15–21	17					17
22–28	57	33	9	8		108
July 29 to Aug. 4	73	21	2		1	99
Aug. 5–11	207	48	1	6	1	263
12–18	116	39		15		170
19–25	133	30		17		180
Aug. 26 to Sept. 1	120	11		20		151
Sept. 2–8	149	74	53	39		315
9–15	46	28	21	16		111
16–22	76	4	14	2		96
Oct. 10–22	11	3	31		2	47
23–29	1		5			6
Totals	1,166	301	143	128	9	1,753

[1] Also, Indian-meal moth, 1 May 13–15, Red flour beetle, 2 July 8–14 and 1 July 22–28, and Saw-toothed grain beetle, 1 May 13–15 and 1 June 10–16.

species of stored-grain insects the flat grain beetle was taken for the first time on April 17, the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), on May 13, the Indian-meal moth, *Plodia interpunctella* Hbn., on May 14, the lesser grain borer on May 15, the foreign grain beetle on June 15, the hairy fungus beetle on June 25, the rice weevil during the first week in July, and the red flour beetle during the second week in July. The flat grain beetle was taken in greatest abundance during the year, with the foreign grain beetle second. The lesser grain borer, one of the most destructive of grain pests, ranked third in numbers taken. Comparatively few rice weevils were trapped. A record of the catch of grain-infesting insects taken in the two traps is given in table 4. It will be noted that, as was the case with the other traps, grain-infesting insects were most abundant during July to September, inclusive.

The preceding record of insects captured in flight, in the vicinity of bins of wheat and actually entering the bins, indicates that during the period of July, August, and September migrating insects constitute an important source of infestation to farm-stored grain. Many of the species caught are of little importance to grain that is in good condition—*e.g.*, the foreign grain beetle and the hairy fungus beetle, which are attracted to high-moisture grain and feed chiefly on molds growing on decaying grain. The lesser grain borer, on the other hand, is a serious pest of stored grain, as is also the rice weevil. The flat grain beetle and the red flour beetle are often associated with heating grain and are often responsible for the caking of surface grain.—10-14-43.

Lt. Col. Stearns in Panama

Lt. Col. Louis A. Stearns, Delaware State Entomologist and head of the Department of Biological Science at the University of Delaware, has been assigned to the Army School of Malariology in this Department after a 14-month tour of duty with the Ninth Air Force in India, Egypt and Libya, and with the Persian Gulf Command in Iran and Iraq, Army officials here announced recently. He is instructor in Entomology in the Army school which is supervised by Col. Charles G. Souder.

Col. Stearns entered the Army on direct commission in June 1942 and completed an eight-week course in the Army School of Tropical Medicine in Washington, D. C., preparatory to his assignment overseas. He was promoted from the rank of major to lieutenant colonel in November 1943, and came to Panama two months later.

M. C. Swingle Now with Dupont

Dr. M. C. Swingle, formerly a member of the Bureau of Entomology and Plant Quarrantine and stationed in the recent past at Sanford, Florida, has joined the expermental staff of the Dupont Experimental Station. His home address is given as 313 Taft Avenue, Wilmington, 182, Delaware.

Dr. E. H. Glass

Dr. E. H. Glass, at one time with the Virginia Agricultural Experiment Station but located for the past year at Ohio State University, is now with the American Cyanamid and Chemical Corporation, 30 Rockefeller Plaza, New York. While we have no direct statement we assume that he is associated with Dr. J. L. Horsfall in his entomological program.

Food Studies of *Geocoris* spp., Predators of the Beet Leafhopper

GEO. T. YORK,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Several species of big-eyed bugs of the genus *Geocoris* (family Lygaeidae) are known to be predacious on insects, but certain of the species have been suspected of causing injury to plants. Usinger (1936) sums up the situation thus: "Almost without exception the early references condemn the bugs as destructive, often simply on the superficial evidence of their occurrence on a given plant. All recent records throughout the world, however, report them as predacious on eggs, nymphs, or even adults of mites, aphids, plant bugs, leafhoppers, etc." Chamberlin & Tenhet (1923) reported *Geocoris punctipes* Say as feeding on flea beetles. Gilmore (1936) observed the same species feeding on eggs of the tobacco hornworm. Knowlton (1937) fed *Geocoris decoratus* (Uhler) on beet leafhoppers, and showed them to be capable of reducing leafhopper populations. Ewing & McGarr (unpublished report 1931) and King & Cook (1932), however, reported that *Geocoris punctipes* (Say) fed on cotton plants in cage experiments and produced positive reactions internally but no external swellings or damage. Lockwood (1933) has reported *Geocoris* spp. and other plant bugs as destructive to cotton in California.

Since several species of the genus *Geocoris* are found commonly associated with the beet leafhopper, *Eutettix tenellus* (Bak.), and since preliminary observations by the writer led to the conclusion that *Geocoris* was destroying large numbers of that insect, it seemed possible that artificial manipulation of these predators might be employed to advantage in the biological control of the pest. Specifically, it was proposed to collect large numbers of *Geocoris* in localities where they were numerous and liberate them in localities where they were not numerous but where large populations of the beet leafhopper were present. Prior to this experiment it was essential to obtain fundamental information on the foods and food requirements of *Geocoris*. Facts to be learned were whether *Geocoris* is predaceous, herbivorous, necrophagous, or polyphagous; if predaceous, its host preferences and average consumption; or, if polyphagous, the foods involved. The results of experiments to determine these points are presented herein.

Experiments were conducted at Modesto, Calif., with two species, *Geocoris punctipes* Say and *G. pallens* Stål,[2] the latter species being used in most cases. No apparent difference was noted between the reactions of the two species. In this paper the term *Geocoris* is used for either or both of the species, unless specific reference is made.

METHODS.—For the determination of food requirements, cylindrical celluloid cages about 2½ inches in diameter by 3 inches long were used. These were covered at the ends with cheesecloth of sufficiently small mesh to retain the insects. Where beet leaves were used in the cages, they were inserted through a hole in the cloth at one end of the cage, and the area around the petiole was made bug-proof with absorbent cotton. Usually five individuals of *Geocoris* were used per cage.

Studies of mean daily consumption of eggs and adults of the beet leafhopper by individual *Geocoris* were conducted in small clip cages, somewhat similar to those described by Giddings (1939) but of an older style. They were about 0.75 inch in diameter by 0.87 inch in height, covered on one end with fine-mesh cloth, and held to the removable glass bottom by rubber bands.

In all previous work noted, the plants on which the insects lived were also present, so the *Geocoris* could have derived their food either from the plants or from the insects. To test which of the two was serving as food, *Geocoris* adults in one set of experiments were given miscellaneous insects collected by random sweeping of plants, or were given other animal matter, but no plants or moisture. In other experi-

[1] Acknowledgements are made of indebtedness to William C. Cook, under whose supervision the work was conducted, for suggestions during the course of the work and for assistance in preparing the manuscript; and to E. W. Davis, M. F. Bowen, C. H. Feltes, and A. A. Barney, all of the Modesto, Calif., laboratory, for suggestions and help.

[2] Specimens were identified in the Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

ments only plants or water were given them.

LONGEVITY ON ANIMAL FOODS ONLY.—In the first test, 3 series of cages were used, with 30 *Geocoris* adults in each series. One series (check) was given neither food nor water, a second series was given dead, refrigerated insects only; and the third series was given hamburger steak only. Previous work has shown that these

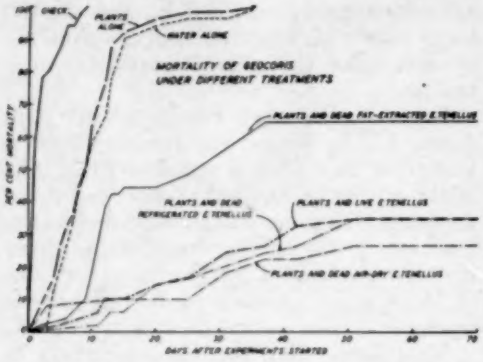

FIG. 1.—The average percentage of mortality of *Geocoris* at intervals during confinement with various foods.

foods could sustain *Geocoris* when plants were present. The mean longevity in all series was less than a day.

In the second test, made at lower temperatures, living beet leafhoppers were used instead of hamburger steak. In this test the *Geocoris* confined without food or water lived 2.58 days, those fed on living leafhoppers lived 2.4 days, and those fed dead miscellaneous insects lived 2.92 days. These differences were not significant.

The result of both tests made it apparent that neither living or dead insects nor other animal matter could sustain the bugs in the absence of plants or water.

LONGEVITY ON PLANT FOOD ONLY.—To test the food value derived from plants in the absence of animal food, a group of *Geocoris* was placed on sugar beet leaves, and a similar group was given only tap water by means of wicks. Checks, in which neither plants nor water was present, were run concurrently. The results of two experiments, involving 270 individuals, showed that those given either plants or water lived about five times as long as those held without either. The mean longevity was slightly, but not significantly, greater in the water cages than in the beet-leaf cages. The fact that water was about equal to beet leaves in sustaining life indicated that plant juices are probably taken, not as food, but only for their moisture content. In the first experiment the individuals given access to water lived, on an average, 6.23 days, those given sugar beet leaves 5.60, and those given no plants or water 1.16 days; whereas in the second experiment the corresponding average durations of life were 10.72, 9.56, and 2.24 days, respectively.

The experiments reported so far indicate that *Geocoris* cannot live long on insects alone, or on plants alone, but apparently must have a combination of the two types of food, or, at least, animal food and water.

LONGEVITY ON VARIOUS FOOD COMBINATIONS.—An experiment was conducted in which 50 adult beet leaf-hoppers each, in four different conditions, were used as animal food in the presence of beet leaves as plant food. The leafhoppers used were (1) alive, (2) dead and preserved by refrigeration, (3) dead and air dried, and (4) dead, the fat having been extracted by ether. The experiment also included (5) a check group in which no food or water was available, (6) a group supplied with water alone, and (7) a group having access to beet leaves alone. The results are shown in figure 1.

In this experiment all the checks were dead within 10 days and all those fed on only plants or water, within 40 days, whereas the larger part of those fed on combinations of animal and plant food lived for more than 70 days. The experiment was terminated at the end of this time because it was midwinter, and the insects were relatively inactive.

There was no significant difference in mortality in the three groups having access to leafhoppers that were not fat-extracted. There was, however, a higher mortality when the fat was extracted, but even with this treatment some food was derived from the leafhoppers. Thus it appears that any beet leafhopper, whether alive or dead, can be utilized as food by *Geocoris*.

LIVING VERSUS DEAD LEAFHOPPERS AS FOOD.—Since it appeared that dead leafhoppers were just as satisfactory for food as live ones, the question arose whether *Geocoris* might not prefer them

to live ones. In other words it might be a scavenger, and become a predator only when dead food was scarce. To check this, three sets of cages were stocked as follows: (1) *Geocoris*, live beet leafhoppers, and dead insects, (2) *Geocoris* and live beet leafhoppers, and (3) live beet leafhoppers without *Geocoris* (check). The dead insects used in the first set were miscellaneous insects collected by sweeping *Atriplex bracteosa* Wats., and included some beet leafhoppers. Beet leaves were present in all cases.

Two such experiments were run at different times, involving a total of 300 *Geocoris* adults and 900 beet leafhoppers. The mortality of *Geocoris* of 4.0 per cent in one experiment and 4.7 per cent in the other was so small that it may be disregarded. The natural mortality of the 300 beet leafhoppers in the check series was 2.0 per cent, while that in the series confined alone with *Geocoris* was 88.3 per cent and in the series where dead insects were also present it was 87.3 per cent. The presence of dead insect matter in abundance made very little difference in the number of living leafhoppers consumed. In other words, living food is preferred, even though dead food is available.

DAILY CONSUMPTION OF LEAFHOPPER ADULTS.—*Geocoris* adults were confined individually in small clip cages on beet leaves with live leafhoppers. Examinations were made daily, the dead leafhopper removed, and live leafhoppers added as mortality occurred. Cages with equal numbers of leafhoppers but without *Geocoris* were run concurrently to determine the natural mortality of the leafhoppers. A summary of this experiment run at two different periods is given in table 1.

Table 1.—Consumption of beet leafhopper adults by *Geocoris*.

Time of Experiment	Geocoris	Leafhopper Days	Leafhopper Mortality	
			Total	Per Insect-Day
July 14–Sept. 30	Present	839	784	.934
	Absent	1,159	445	.384
	Difference (consumed by *Geocoris*)			.550
Nov. 10–Dec. 14	Present	521	37	.071
	Absent	525	9	.017
	Difference (consumed by *Geocoris*)			.054

The mortality that could be attributed directly to *Geocoris* amounted to 0.550 leafhopper per day per *Geocoris* during the summer. This is close to the figure 0.50 derived from summarizing the experiments by Knowlton (1937). The number represents the minimum, as the weaker leafhoppers, such as caused the natural mortality in the check cages, were probably consumed first by the predators, because they could be most easily captured. Feeding was greatly reduced during cold weather, as shown by the mean of only 0.054 during the period from November 10 to December 14.

FIG. 2.—Photomicrograph of section of beet leaf showing eggs of the beet leafhopper. A group of five uninjured eggs appears in the upper right-hand corner, while two eggs fed upon by *Geocoris* appear at the upper left, as well as one at right center.

Leafhopper nymphs are also used as food by *Geocoris*, but no attempt was made to determine the mean daily consumption.

BEET LEAFHOPPER EGGS AS FOOD.—Preliminary work showed that *Geocoris* also destroyed leafhopper eggs embedded in plant tissue. Tests were made to determine whether these were satisfactory as a food, and if so, how many could be consumed in a day.

Small clip cages, each containing three female beet leafhoppers, were placed on a beet leaf. These were shifted twice a week to new areas of the leaf, and a single *Geocoris* adult was caged on the portion of the leaf from which they had been removed. This gave the predator access only to the beet leaf and the eggs which had been deposited in it. To determine the number of eggs destroyed, the portion of beet leaf was placed in benzol-chloral hydrate solution for about 1 hour, removed to glycerin, and examined under the binocular

microscope. Eggs that had been fed upon were wrinkled in appearance, and easily distinguished from good eggs. The difference in appearance is shown in the photomicrograph (Fig. 2).

To determine the suitability of leafhopper eggs as food, the *Geocoris* adults were given access to beat leaves with and without leafhopper eggs. Three groups of the predators, containing 14 to 26 individuals each, and consisting of *Geocoris pallens* adults, *G. pallens* nymphs, and *G. punctipes* adults, were tested. When given access only to beet leaves, not containing eggs, all the *G. pallens* nymphs and *G. punctipes* adults died within 20 days, and all the *G. pallens* adults were dead by the 24th day. At the time of total mortality in the groups having leaves only there had been 20 per cent mortality of the *G. pallens* nymphs, 37.5 per cent mortality of the *G. punctipes* adults, and no mortality among the *G. pallens* adults, on the leaves containing leafhopper eggs. The feeding on leaves containing leafhopper eggs was continued for some time after the check groups had succumbed. There was still no mortality among the *G. pallens* adults at the end of 55 days, showing conclusively that leafhopper eggs were an entirely satisfactory food for this species.

DAILY CONSUMPTION OF LEAFHOPPER EGGS.—In the test just reported, male adults of *Geocoris pallens* consumed an average of 2.16 ± 0.11 eggs per day, and females an average of 3.55 ± 0.14 eggs per day. The mean numbers of eggs available for feeding were 4.85 ± 0.32 and 4.74 ± 0.19, respectively, so feeding was not limited by the number of eggs present.

During the early part of the experiment, egg consumption was rather low because of low temperatures. By eliminating this cold period an approximation to feeding under average summer conditions was obtained. Egg consumption was somewhat higher in the warm weather, being 2.54 ± 0.17 eggs per day for males and 4.13 ± 0.17 for females.

As a verification of the above experiment, a second group of adults which had recently emerged was fed on leafhopper eggs from May 29 to July 10. The mean number of eggs consumed daily by males was 2.80 ± 0.13 and by females 3.99 ± 0.34. These figures are not significantly different from those just given, but there was a significant difference between males and females in both groups. From these data it may be concluded that under average summer conditions in central California *Geocoris pallens* males consume about 2.5 beet leafhopper eggs a day and the females about 4, when no other food is available.

CONCLUSION.—It is concluded, on the basis of information obtained in the investigations reported on in this article, that, insofar as foods and food requirements of the two species of *Geocoris* studied are concerned, it would be feasible to perform large-scale tests in the artificial manipulation of these predators in the biological control of the beet leafhopper.

SUMMARY.—The experiments reported in this paper were designed to determine the role of plants and animals as food for *Geocoris punctipes* Say and *G. pallens* Stål, as fundamental information needed in a projected attempt to utilize these predaceous insects in the biological control of the beet leafhopper. Cage experiments conducted at the Modesto, Calif., laboratory showed that these two species of *Geocoris* could not live on insects alone or on plants alone, but required a combination of the two. Apparently the plants served only as a source of water.

With plants available, *Geocoris* lived equally well on beet leafhoppers alive, dead and preserved by refrigeration, or dead and air dried. The mortality was increased, however, if the leafhoppers furnished as food had been treated in ether, although even then some sustenance was available.

The presence of dead leafhoppers did not reduce feeding on live leafhoppers.

During the summer the *Geocoris* adults consumed about one adult leafhopper every 2 days.

The predators consumed eggs of the beet leafhopper, which were laid in plant tissue. The average daily consumption by *Geocoris pallens* during the summer was 2.5 eggs per day for males and 4 eggs per day for females.

It was concluded that it would be practicable to experiment with these predators as a factor of natural control.—10-16-43.

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The Development of Large Differences in the Ability of Local Codling Moths to Enter Sprayed Apples

L. F. STEINER, C. H. ARNOLD and S. A. SUMMERLAND, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Since Hough (1928, 1934) demonstrated that Virginia and Colorado strains of the codling moth, *Carpocapsa pomonella* (L.), were substantially different in their ability to enter sprayed fruit, many persons connected with the apple industry believe that the use of lead arsenate is causing the codling moth to develop a resistance to this insecticide.

Large unaccountable differences in the intensity of spray programs required to control the insect in the three-brood area of the Middle West support this belief and suggest that the populations in local orchards may differ greatly in their susceptibility to insecticidal sprays. Experiments started in 1942 at the Vincennes, Ind., laboratory indicate that such differences do exist and may be as great as the regional differences noted by Hough.

SOURCE OF LARVAE.—Samples of the codling moth population from two orchards were compared. These orchards are centered in localities where the codling moth has been a major apple pest for more than 50 years, and where the control obtained with heavy arsenical sprays has been unsatisfactory. Largely because of this condition, more than 60 per cent of the acreage in one of the localities has been abandoned in the past 12 years. Both orchards under study are sufficiently isolated to prevent inter-breeding of their codling moth populations with those of other orchards. They are 37 miles apart in an east-and-west direction in the Ohio and lower Wabash Valleys under similar conditions of elevation and climate. Both orchards were sprayed alike with lead arsenate until 1936 when, largely because full schedules of lead arsenate sprays were no longer controlling the insect, one of the orchards, henceforth designated A, was abandoned. No sprays have been applied since. The other orchard, designated B, is still being given heavy lead arsenate sprays, supplemented with mineral oil, oil and soap, bordeaux mixture, or lime. The crops in both orchards have been almost totally injured by the codling moth for several years.

METHODS.—Approximately 15,000 larvae collected from each orchard in the fall of 1941 and placed in cold storage in March 1942 were removed from storage in June. The moths which emerged from late June through July were placed in oviposition cages. Newly hatched larvae from the two sources were applied concurrently within 30 minutes after hatching, to paired apples sampled from various field plots, which had been sprayed with lead arsenate, nicotine, xanthone, phenothiazine, or cryolite. In some tests 8 larvae were used per apple, in others 10.

Other tests were carried on in the orchard. Newly hatched larvae of each strain were released concurrently on the foliage of bearing spurs, generally 2 or 3 inches from the nearest apple, on trees receiving different spray treatments.

DIFFERENCES IN ABILITY OF LARVAE

TO ENTER FRUIT.—Preliminary tests, in which more than 2600 newly hatched larvae from each source were used, showed that the *B* strain was able to enter fruit sprayed with lead arsenate or nicotine in much larger numbers than the *A* strain.

Table 1.—Results of tests indicating differences in the ability of two local strains of codling moth larvae to enter or sting sprayed Grimes Golden apples, Vincennes, Ind., July 8 and 20, 1942.

Treatment	Date	Strain A		Strain B	
		Worms	Stings	Worms	Stings
	July				
Unsprayed	8	87.0	3.5	88.5	3.2
	8	85.8	1.2	85.8	3.0
	20	83.1	2.8	85.9	2.9
Lead arsenate and weak bordeaux mixture	8	5.8	28.0	48.5	18.0
	20	14.4	24.7	40.0	11.9
Lead arsenate, weak bordeaux mixture, and spreader	8	7.0	32.2	46.0	24.8
	20	10.6	24.8	38.4	10.6
Lead arsenate, zinc sulfate, and lime	8	12.0	30.0	53.2	23.0
	20	11.2	30.9	49.7	10.9
Lead arsenate, xanthone, zinc sulfate, and lime	8	18.2	36.5	54.5	30.5
	20	29.0	26.9	61.6	9.1
Cryolite and mineral oil, lead arsenate in early sprays	20	19.4	34.7	56.9	10.9
Tank mix nicotine sulfate, bentonite, and soybean oil	8	7.8	1.2	15.0	2.8
	20	10.6	1.9	23.1	1.2
Factory processed nicotine bentonite and soybean oil	8	9.8	3.5	20.0	4.8
	20	20.3	3.8	27.2	4.4
Micronized nicotine bentonite and soybean oil	8	4.8	1.8	10.2	0.5
	20	10.6	0.9	24.7	1.6
Micronized nicotine bentonite, mineral oil, and protein spreader	8	7.2	1.5	17.0	4.5
	20	16.9	0.6	27.5	3.8

On July 8 and 20, during the period following the fifth cover spray which had been applied on July 3, more extensive tests were conducted in the laboratory with fruit sprayed in the orchard. Four hundred larvae of each strain were used per treatment in the tests conducted on July 8, and 320 larvae in those of July 20. The variety was Grimes Golden. The results of these are given in table 1.

With the lead arsenate treatments the worm survival for the *B* strain was from 2 to 8 times that of the *A* strain. The differences were all statistically significant, most of them at odds of more than 1000 to 1. Worms of the *A* strain, however, produced more stings. With the nicotine bentonite treatments, no differences in per cent worms were significant at odds of 99 to 1 although all but two were significant at odds of 19 to 1. Sting injuries were not significantly different. There was no difference in the ability of the two strains to enter unsprayed fruit. This is contrary to Hough's results with Colorado and Virginia larvae.

In table 2 are given the results of an experiment in which Rome Beauty apples from orchards sprayed with lead arsenate and nicotine bentonite were used. Again no difference was noted in the ability of the two strains to enter clean fruit and larger differences were found with lead arsenate than with nicotine bentonite.

In the foregoing tests the larvae entered the fruit under controlled laboratory conditions and escaped the effect of many orchard variables including deposits on foliage. On July 31 and August 1 newly hatched larvae of each strain were released concurrently on adjacent trees in two experimental plots. On two unsprayed trees 250 of each strain were released. Eighty-one per cent of the *A* strain and 80 per cent of the *B* strain successfully entered the fruit. On trees sprayed with lead arsenate 500 larvae of each strain were released. Only 1.6 per cent of the *A* strain survived and 14.6 per cent made stings, while 8.2 per cent of the *B* strain survived and 51.0 per cent made stings.

RELATIVE SUSCEPTIBILITY IN EGG STAGE.—The results of ovicidal tests in which apples containing eggs of 3 age groups of each strain were sprayed on a laboratory precision sprayer are given in table 3.

Table 2.—Results of tests indicating differences in the ability of two local strains of codling moth larvae to enter or sting Rome Beauty apples sprayed with lead arsenate or nicotine bentonite, Vincennes, Ind., July 10, 1942.

Spray Treatment	Larvae of Each Strain	Strain A		Strain B	
		Worms	Stings	Worms	Stings
		%	%	%	%
Nicotine bentonite, fruit washed to remove residues	300	65.0	1.0	63.0	4.3
Nicotine bentonite[1]	1800	19.0	3.4	27.2	5.9
Lead arsenate, lime and oil[2]	1800	13.2	29.3	36.3	14.1

[1] The difference in percentage of worms is significant at odds of 19 to 1.
[2] The difference in percentage of worms is significant at odds of 99 to 1.

Eggs which had reached the age of 6 days had started to hatch. The four treatments represent ovicides that function in different ways, yet no difference in the resistance of the two strains of eggs to these sprays could be detected. Xanthone,

found by Steiner & Summerland (1943) to be highly toxic to eggs when applied under orchard conditions where sunlight and other factors apparently increase it toxicity, had little effect on eggs in the laboratory. Micronized nicotine bentonite allowed the eggs to develop to the black-spot stage and in some cases did not kill the embryo until it had cracked the shell. Mineral oil, alone and with nicotine, destroyed the eggs whatever stage they were in when sprayed.

Hough (1934) showed that eggs from Colorado moths were more resistant to fumigation with hydrocyanic acid than eggs of Virginia moths when the eggs were in the more advanced stages of development, but found no difference in tolerance to cyanide fumigation when the eggs were fresh.

RELATIVE VIGOR OF LARVAE OF THE TWO STRAINS.—Hough (1934) found, as did Haseman & Meffert (1933), that mature larvae from Colorado and Virginia sources were alike in their susceptibility to toxicants, and concluded that the difference shown by newly hatched larvae and the mature embryos was one of general vigor, or power of recovery, inherent in the individual. The equal ability of strains *A* and *B* to enter unsprayed fruit under both laboratory and orchard conditions and the equal susceptibility of all stages of their eggs to different types of ovicides suggest that general vigor may not be the factor responsible for differences in these local strains. Further indication that general vigor is not responsible for the differences in the two local strains may be found in the fact that the two strains were about equal in their ability to enter Grimes apples sprayed with phenothiazine, which kills largely by contact.

DIFFERENCES IN LARVAL BEHAVIOR.—The possibility that in the reaction of the larvae to external stimuli inherent differences have developed which may affect their behavior has been given preliminary consideration. Morphological differences, particularly in the shape of the mouth parts, could also affect behavior.

In one experiment 200 larvae of each strain were placed on 20 paired halves of apples ringed with tanglefoot to prevent their escape. Half of the apples had been sprayed with lead arsenate and half were unsprayed.

On the unsprayed fruit 78 per cent of the *A* strain eventually entered and 85 per cent of the *B* strain, but 45 minutes after being placed on the fruit only 53 per cent of the *A* strain had settled and were making progress in cutting through the skin compared with 76 per cent of the *B* strain. In the same period 31 per cent of the *A* strain were cutting through lead arsenate deposits compared with 48 per cent of the *B* strain. Of the *A* strain 24 per cent eventually survived the poison and 15 per cent made stings, while of the *B* strain 58 per cent survived and 2 per cent made stings. It is significant that of the larvae that cut through the skin of sprayed fruit 79 per cent of the *A* strain and 80 per cent of the *B* strain had settled and were cutting pieces of the fruit tissue loose within 45 minutes.

Table 3.—Results of tests with ovicides applied to three ages of eggs from strains A and B of the codling moth.

TREATMENT (MATERIALS PER 100 GALS.)	AGE WHEN SPRAYED HOURS	STRAIN A		STRAIN B	
		Number	Per Cent Dead	Number	Per Cent Dead
Xanthone, 2 lbs., kerosene, 1 qt., and adhesive	4–48	149	6.9	246	1.2
	49–96	297	5.4	197	4.1
	97–144	102	5.4	175	7.4
Micronized nicotine bentonite (8.1% nicotine), 3.5 lbs.	4–48	202	10.9	218	10.6
	49–96	199	29.1	250	28.8
	97–144	201	44.3	287	39.4
Mineral oil, 2 qts.	4–48	116	77.6	171	81.9
	49–96	384	90.9	159	91.2
	97–144	236	58.5	214	58.9
Nicotine sulfate (40%), 0.67 pt., mineral oil, 2 qts.	4–48	36	83.3	139	84.9
	49–96	288	94.8	199	94.5
	97–144	166	74.7	191	79.1

In other experiments in which 77 larvae from each of the two sources were paired and applied simultaneously to segments of unsprayed fruit and timed until each had spun its web and cut loose the first piece of tissue, the average time interval for the *A* strain was 61 minutes compared with 38 minutes for the *B* strain.

Larvae of the *A* strain crawled longer distances before attempting to effect their entrances. On sprayed fruit they would therefore be more susceptible to poisoning, and slow-acting poisons such as lead arsenate would have time to affect more of them if picked up before entrance was attempted. They might also lose moisture more rapidly and die from this cause in a shorter period of time than those of the *B* strain.

RELATIVE RATES OF REPRODUCTION.—

It has been suggested by Smith (1941) that the reproductive capacity of races with low "resistance" to insecticides may be greater than that of more resistant races. However, no difference in the numbers of eggs deposited by moths of the *A* and *B* strains could be found.

DISCUSSION.—Since the two orchards were sprayed alike until 1936, the chances are great that the differences in the ability of their populations to enter sprayed fruit have developed in the past 5 years through not more than 15 generations.

It is highly improbable that any insecticide program would prevent the maintenance of some variants with low resistance in a population, not only because complete coverage of all apples with a film of spray is almost impossible of accomplishment with less than three applications but also because of genetic expectation. Meanwhile some of the population has an opportunity to survive without encountering the insecticide. It is possible therefore that the less resistant variants in the population of Orchard A became the more abundant during the 5 years that elapsed since spraying ceased. It must also be recognized that heavier applications in recent years in Orchard B may have eliminated a high percentage of the more susceptible individuals, and thus increased the average ability of larvae to survive in sprayed fruit. The continued use of heavy lead arsenate sprays might eventually bring racial segregation to a point where the apparent differences in general vigor noted by Hough (1934) could be detected.

It is probable that by making readjustments in control practices growers can retard increases in the proportion of larvae of resistant races. Since the eggs of the *A* and *B* strains were equally susceptible to ovicides, more use of such sprays could be made. Insecticides which contribute to control by killing the adults might also help keep resistant variants from becoming more numerous. The use of bait traps and of bands, the sealing of packing sheds, and the practice of orchard sanitation should also be of assistance. If it is eventually found that the less resistant variants have a higher reproductive capacity, the use of control measures which reduce the number of sprays required may make it possible for such strains to maintain preponderance in an orchard even where lead arsenate is used. Furthermore, the use of insecticides other than lead arsenate for a few years might allow less resistant variants to resume preponderance.

Although the *B* strain in these tests was able to enter fruit sprayed with nicotine bentonite in larger numbers than the *A* strain, it does not follow that a strain resistant to nicotine can be segregated by use of nicotine sprays. These kill more adults and eggs than does lead arsenate, hence a smaller proportion of the population would be subject to them as larvae. This requires further investigation. It is important to note that the difference in the ability of larvae to enter fruit sprayed with nicotine was enough less than that of their ability to enter fruit sprayed with lead arsenate to reverse the relative efficiency of the two insecticides when they are associated with different races. In general, nicotine bentonite was more effective than lead arsenate in controlling strain *B* but was less effective than lead arsenate against strain *A*. This may partly account for the excellent results frequently obtained with nicotine bentonite in orchards where lead arsenate has failed to give control.

Obviously, the degree of resistance to lead arsenate exhibited by a local population can have an important bearing on the results of experimental tests in which other insecticides are included. It will affect the reproducibility of such tests in other orchards even within the same local area. The need for surveys designed to ascertain the variation among orchard populations of codling moth larvae with respect to their ability to enter sprayed fruit is evident, particularly in localities where experimental tests are being conducted.

SUMMARY.—Laboratory and orchard tests with more than 14,000 newly hatched codling moth larvae from each of two similarly situated orchards in the Ohio and lower Wabash Valleys show that differences between populations in their ability to enter sprayed fruit have apparently developed within the last 5 years. The orchards were sprayed alike prior to 1936. Larvae from one, which has since been sprayed heavily with lead arsenate, were able to enter fruit sprayed with lead arsenate, nicotine bentonite, cryolite, or xanthone, but not phenothiazine, in sig-

nificantly greater numbers than larvae from the other orchard, which was not sprayed after 1936.

No differences could be found in the ability of the two strains to enter unsprayed fruit or in the resistance of their eggs to xanthone, micronized nicotine bentonite, mineral oil, or mineral oil-nicotine sprays.

Observations indicated that the strain least susceptible to lead arsenate used less time in attempting entrance and crawled shorter distances over sprayed fruit than the more susceptible strain, a fact suggesting that the difference in so-called resistance was behavioristic rather than one of general vigor.

Apparent resistance of the one strain to lead arsenate was considerably greater than to nicotine, consequently nicotine gave better results than lead arsenate in laboratory tests against the more resistant strain but poorer results against the less resistant strain.

The results suggest that increases in the proportion of resistant strains in a codling moth population can be retarded, if not prevented, by utilizing more supplementary measures and insecticides that kill more of the adults and eggs than does lead arsenate. They also show the need for a survey of the variation in apparent resistance that may exist among different orchard populations in localities where comparative tests of insecticides are being made.—10-13-43.

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Changes in Ratio of Lead to Arsenious Oxide in Lead Arsenate Residues on Apples

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In a previous paper Fahey & Rusk (1939) reported the results of determinations of the ratio of lead to arsenious oxide in acid lead arsenate spray deposits studied during 1935 and 1936. Their data failed to show any significant changes in ratio in such deposits as are commonly encountered in the orchards of southern Indiana. They further pointed out that this was contrary to the results of early investigations, in which ratios of lead to arsenious oxide in excess of 4:1, as compared with 2.09:1 for pure acid lead arsenate, were not uncommon. The observations of Harman (1937), Frear & Worthyley (1937), and Pearce and Avens (1938) were cited as evidence to support the supposition that ratios in excess of 4:1 were in all probability due to inadequate sampling or unreliable methods of analysis. Pearce & Avens (1940), in a second paper on this subject, pointed to the agreement between their results and those previously reported by Fahey and Rusk (1939) where comparable spray treatments were employed, but justly criticized the fact that only lead arsenate-bordeaux and lead arsenate-bordeaux-oil residues had been studied by these writers. They further showed that the decomposition of simple lead arsenate residues was negligible, that the addition of lime to the spray mixture increased, whereas bordeaux mixture or oil tended to decrease, the rate of change of ratio of lead to arsenious oxide during periods of weathering, and that as the

[1] The author acknowledges the assistance of H. W. Rusk in the analytical work of this investigation.

The plots used in the experiments reported in this paper were sprayed by personnel of the Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

number of sprays was increased this ratio in the harvest residue departed less from that of acid lead arsenate.

Because of the debatable significance of the existing data regarding lead-arsenious oxide ratios in lead arsenate, it was considered advisable to investigate the subject further. During the 1941 season an experiment was set up for the examination of lead arsenate residues resulting from various types of sprays. Through an improved method of study the writer has been able to obtain a better measure of the change in ratio. It is the purpose of this paper to present the results of this study, conducted at Vincennes, Indiana, which confirms the previous findings and those reported by Pearce & Avens (1940).

METHODS.—An orchard of Grimes Golden apple trees was divided into six plots which received the following spray treatments:

Plot 1. Lead arsenate alone, 7 cover sprays
Plot 2. Lead arsenate-lime, 7 cover sprays
Plot 3. Lead arsenate-mineral oil, 6 cover sprays following 1 cover spray of lead arsenate alone.
Plot 4. Lead arsenate-bordeaux, 4 cover sprays
Plot 5. Lead arsenate-bordeaux-wetting agent, 7 cover sprays
Plot 6. Lead arsenate-bordeaux, 7 cover sprays; mineral oil added in second, third, and fourth cover sprays.

The materials employed were all commercial preparations. Analysis of the lead arsenate employed showed an initial lead arsenious oxide ratio of 2.10:1.

Samples were taken from each plot following the second and subsequent cover sprays, at the end of the weathering period of each spray, and at harvest. In addition, a part of each plot was left unsprayed after the fourth cover spray so that the effect of prolonged weathering might be studied. These trees were sampled 17, 31, 45, and 89 days after the final cover-spray application.

Samples of 40 or 50 fruits were taken from 3 levels of the tree and from 2 or more positions at each level to assure a representative sample. Each sample was divided into 4 or 5 replicates of 10 fruits each for chemical analysis of the spray residues. From the analytical data determined there was obtained not only the mean ratio of lead to arsenious oxide but also a measure of the variation within samples. By statistical analysis of these data the variation between samples can be separated from the experimental error and the difference calculated that is required for significance between the mean ratios of the samples analyzed. In their previous study Fahey and Rusk (1939) relied on duplicate a 25-fruit samples which did not show the within-sample variation adequately, much greater differences were required to indicate significance. As in that study, arsenic was again determined by the bromate method (Association of Official Agricultural Chemists 1933; Jones 1934) and lead by the electrolytic precipitation and titration method (Wichmann *et al.*, 1934).

DISCUSSION.—Tables 1 and 2 show the mean ratios of lead to arsenious oxide resulting from the analysis of the 4 or 5 subsamples of each sample taken and the difference for significance at odds of 99 to 1. The magnitude of the difference required for significance varies greatly between spray treatments. This is the result of the within-sample variation of the several types of residues studied. The residues that show a very small change in ratio of lead to arsenious oxide (plots 1, 3, 4, 5, and 6) show a relatively small difference required for significance. Plot 2, which shows a greater change in ratio, also shows a greater within-sample variation; therefore, a greater difference between means of samples is required for significance.

The magnitude of the difference required for significance is attributed to the spray treatment rather than to sampling. This conclusion is justified by the following reasoning: If a residue is only slightly affected by weather, the position of the fruit on which the residue is deposited, with respect to exposure to the elements, would have only a small effect on the ultimate ratio of lead to arsenious oxide in that residue. On the other hand, if the residue is much affected by the weather, the position of the fruit with respect to exposure becomes an important factor in any change in ratio of lead to arsenious oxide in the residue. Thus the within-sample variation of samples taken from plots subjected to such spray treatments

Table 1.—Ratios of lead to arsenious oxide in spray-residue deposits studied during the 1940 growing season, based on 10-fruit replicates.

Cover Spray and Date of Sampling	Replicates	Rain Between Samplings Inches	Average Lead-Arsenious Oxide Ratio: Lead Arsenate with Alone Plot 1	Lime Plot 2	Mineral Oil Plot 3	Bordeaux Plot 4	Bordeaux, Wetting Agent Plot 5	Bordeaux, Mineral Oil Plot 6
Second:								
May 26	5		2.08	2.14	2.04	2.07	2.08	2.10
June 2	5	1.46	2.09	2.12	2.17	2.09	2.04	2.07
Third:								
June 3	5		2.12	2.08	2.09	2.09	2.10	2.09
June 10	5	1.66	2.22	2.42	2.24	2.15	2.20	2.18
Fourth:								
June 13	5		2.19	2.52	2.20	2.16	2.16	2.16
June 30	4	0.28	2.25	2.60	2.30	2.21	2.19	2.21
Fifth:								
July 2	4		—	2.40	2.28	—	2.27	2.22
July 14	4	0.46	—	2.50	2.24	—	2.21	2.18
Sixth:								
July 16	4		2.20	2.32	2.20	—	2.23	2.19
July 28	4	1.66	2.20	2.62	2.25	—	2.13	2.12
Seventh:								
July 30	4		2.24	2.45	2.24	—	2.23	2.17
Sept. 10	4	5.94	2.37	3.04	2.34	2.30	2.24	2.25
Least Significant Difference at Odds of 99 to 1								
	4		0.11	0.26	0.14	0.16	0.07	0.09
	4 and 5		0.11	0.24	0.13	0.15	0.07	0.08
	5		0.10	0.23	0.13	0.14	0.07	0.08

as favor rapid changes from weather would be greater than in samples taken from other treatments which were not so subject to weathering.

The results of the weathering of residues are given in table 1. Except for plot 4, all plots received seven cover sprays. Plot 2, lead arsenate-lime, shows a significant change in ratio of lead to arsenious oxide in three of the six weathering periods studied. Plot 4, lead arsenate-bordeaux, does not show a significant change during any of the periods of weathering. There are only two periods of weathering during which any of the four other treatments show significant changes in ratio. These periods are June 3 to 10 and July 30 to September 10. The precipitations during these periods were 1.66 inches and 5.94 inches, respectively. Plot 1 (lead arsenate alone), showed a significant change in ratio of lead to arsenious

Table 2.—Ratio of lead to arsenious oxide in spray-residue deposits subjected to extended period of weathering, based on 10-fruit replicates.

Date	Replicates	Days After First Analysis	Rain Between Samplings, Inches	Average Lead-Arsenious Oxide Ratio: Lead Arsenate with Alone Plot 1	Lime Plot 2	Mineral Oil Plot 3	Bordeaux Plot 4	Bordeaux, Wetting-Agent Plot 5	Bordeaux, Mineral Oil Plot 6
June 13	5	0	—	2.19	2.52	2.20	2.16	2.16	2.16
June 30	4	17	0.28	2.25	2.60	2.30	2.21	2.19	2.21
July 14	4	31	0.46	2.32	2.73	2.26	2.18	2.22	2.21
July 28	4	45	1.66	2.34	2.82	2.27	2.26	2.22	2.24
Sept. 10	4	89	5.94	2.53	3.03	2.44	2.30	2.32	2.25
Least significant difference at odds of 99 to 1				0.17	0.29	0.11	0.09	0.07	0.07

oxide during both these periods of weathering. Plot 3 (lead arsenate-mineral oil), plot 5 (lead arsenate-bordeaux-wetting agent), and plot 6 (lead arsenate-bordeaux-mineral oil), showed a significant change during only one.

Table 2 shows the weathering of the residue from the first four cover sprays through the remainder of the growing season. All the residues show a gradual increase in ratio of lead to arsenious oxide during the period of study. It is not until after 45 days of weathering, however, during which 2.4 inches of rain fell, that any of the changes in ratio became significant. The changes in ratio in residues on plots 1, 3, and 5 were not significant until the final samples was taken 89 days after the initial analysis.

It was thus shown that, when lead arsenate was used without auxiliary spray materials, the change in ratio of lead to arsenious oxide in the residue deposit became significant only when the residues were allowed to weather for extended periods. The addition of mineral oil, bordeaux mixture, or both, to the spray reduced the rate of decomposition. The addition of lime accelerated the rate of decomposition, the changes in ratio being relatively great and significant even when the weathering period was short.

These conclusions confirm the results of Pearce & Avens and also confirm the previously reported results of Fahey & Rusk. By improving the methods of study it has been possible to show some of these small differences in ratio of lead to arsenious oxide to be significant at odds of 99 to 1.—10-5-43.

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Xanthone in the Control of Codling Moth and Mites on Apples and Pears in California[1]

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In the search for a substitute for lead arsenate in the control of codling moth on apple and pear, a number of commercial products have been tested in the field. These have included natural cryolite, nicotine bentonite, phenothiazine, xanthone[2] and an amine salt of dinitro-o-cyclohexyl phenol (*DN-111*).

The purpose of these investigations was to find a material which could safely and efficiently be used in the cover sprays following lead arsenate in the first applications commonly called the calyx sprays. Though no material has been found which surpasses lead arsenate, especially in the calyx sprays, the use of the latter throughout the season usually results in a high lead and arsenate residue which requires careful and adequate washing to meet the federal tolerance. Furthermore, in the coastal areas where most of the apples in this state are grown, the use of standard lead arsenate throughout the spray season frequently results in foliage injury, especially during the months of

[1] Early publication of this paper has been secured by payment of the costs of printing.

[2] A product manufactured under the name Genicide by the General Chemical Co.

June, July and August, when the orchards are frequently bathed in fog. In the pear growing areas the lead arsenate program fails to protect the fruit from the attacks of the European red mite, *Paratetranychus pilosus*, and the two-spotted mite, *Tetranychus bimaculatus*, unless summer oil emulsion is added to the late lead arsenate cover sprays. The addition of oil in these late sprays (June-July) just prior to harvest, complicates residue removal, is expensive and may cause fruit and foliage injury. Under California codling moth conditions the ideal program would include the use of two lead arsenate sprays followed by from two to four cover sprays of a suitable substitute material. The number of cover sprays depends upon the severity of the infestitation and the time of harvest in relation to second brood attack. The substitute material should not only control codling moth but should also prevent mite and spray injury to foliage and fruit and leave no objectionable residue.

Field investigations over a number of years have shown that some of the materials tested are adequate to meet all these requirements. Xanthone is one of the most promising of these materials and may soon be available for commercial use.

EXPERIMENTAL DATA.—*Rose Orchard, Sacramento 1939.* In a Bartlett pear orchard heavily infested with codling moth the previous season, a randomized plot was sprayed with a program which included:[1]

Two 4-pound arsenate sprays and five 2-pound xanthone cover sprays;

Three 4-pound lead arsenate sprays and four 2-pound xanthone cover sprays and seven 4-pound lad arsenate sprays as a check.

The calyx sprays were applied April 5 and 20, and the cover sprays on May 5 and 16, June 1 and 19, and July 7. Each treatment was replicated 7 times and a 100-fruit randomized sample and all drop fruits were taken from each tree at harvest. The spreader used with the xanthone was composed of 1 pound of whale oil soap and 1 pound of hydrated lime and caused excess run-off and light deposits. The fruit counts at harvest (July) are summarized in table 1.

At harvest and during the rest of the season it was noted that the xanthone-sprayed trees suffered no injury from mite attack, whereas the lead arsenate-sprayed trees were almost completely defoliated by mites soon after harvest. Residues of lead and arsenic at harvest on unwashed fruits from the first two treatments were below the tolerances allowed.

Burbank Orchard, Sebastopol. 1940. A randomized plot of Red- and Golden-Delicious apples consisting of 4-tree units with four replicates was sprayed with two 4-pound lead arsenate sprays and three cover sprays. The Red Delicious apples were harvested September 6 and the Golden Delicious on September 26. At harvest, two boxes of picked fruit and all windfalls from each tree were examined. The spray schedule was as follows:

All trees received two calyx sprays of astringent lead arsenate plus 5 ounces *Multifilm* spreader and 1 quart kerosene per 100 gallons. Cover sprays, applied June 22, July 4 and August 2, were, 2 pounds xanthone, 6 ounces *Genispred* and 1 quart kerosene per 100 gallons; 3 pounds xanthone, 6 ounces *Genispred* and 1 quart kerosene per 100 gallons; 4 pounds lead arsenate, 5 ounces *Multifilm* and 1 quart kerosene per 100 gallons.

The spreaders used gave good, film-type deposits with very little run-off. Analyses of xanthone deposits showed an average deposit of 52 mg. per square inch for the first treatment and 73 mg. per square inch for the second treatment after the second application. Counts of more than 1200 fruits from each treatment are shown in in table 1.

It was noted that the leaves on the xanthone sprayed trees were larger and of a darker green color than those from the trees receiving only lead arsenate, and that the latter showed considerable arsenical injury and a fairly heavy leaf drop.

Leary Orchard, Ryde. 1940. Mite damage to Bartlett pears is often severe, especially on trees adjoining dusty driveways in the orchard. Partial to complete defoliation over the entire orchard frequently occurs prior to, or following, harvest. A plot consisting of 30 trees was divided into six units of five trees each, and alternate units received (July 12) a single application of 3 pounds xanthone, 8 ounces *Genispred* and no kerosene, while the other three units received the usual 3-pound dosage of lead arsenate plus spreader. Mite counts on 10 leaves per tree were made soon after the application

[1] All spray formulas in this paper are based on units of 100 gallons completed spray mixture.

and also on August 5. They showed the following:

On July 12 with xanthone treatment, an average of 1.8 immature and 2.8 mature mites per leaf; Lead arsenate treatment 5.2 immature and 29.3 mature mites per leaf.

On August 5, xanthone-treated leaves showed 0.5 immature and 4.1 mature mites per leaf while the lead arsenate treatment showed 73.7 immature and 21.2 mature mites.

At the time of the second count the lead arsenate-sprayed trees showed severe leaf injury clear to the tops of the trees, while the xanthone-sprayed trees had very little foliage injury. Although the mites were still present on the leaves of xanthone-sprayed trees, there was apparently little or no damage.

Swett Orchard, Martinez, 1940. As a test of tolerance, a block of four large Bartlett pear trees were sprayed on April 12 and 29, June 6 and July 8 with 4 pounds xanthone, 5 ounces *Genispred* and 1.5 pints kerosene per hundred gallons of spray. No injury to fruit or foliage was apparent at harvest (July 30) and the foliage remained dark green quite late in the season.

McKain Orchard, Larkin Valley 1940. On a randomized plot of 36 Winter Banana apples two cover sprays were applied (June 12 and July 18) following two standard lead arsenate sprays. The formulae of the cover sprays were:

Xanthone, 2 pounds, *Genispred* 8 ounces, kerosene 1.5 pints

Cryolite (natural), 3 pounds, light summer oil 2 pints

Nicotine bentonite 5 pounds, light summer oil 2 pints

Two separate pickings were made (August 24 and September 10); two boxes of picked fruit and all the windfalls from each tree were examined at each picking. The summary of fruit counts will be found in table 1. Due to the blotched type of deposit obtained with the cryolite and nicotine bentonite there was considerable mottling of the highly colored cheeks of the fruits by these two materials whereas the xanthone treatment left fruits of high uniform coloring.

Flath Orchard, Watsonville, 1942. Plot A. A randomized plot of Yellow Newtown Pippins with eight replicates was used to test the efficiency of four substitute materials in codling moth control. Natural cryolite, nicotine bentonite, phenothiazine and xanthone were applied in four cover sprays following two lead arsenate sprays. As a check, 8 trees received only the two calyx sprays. Cover sprays were applied May 18, June 2, July 7, and August 3. Harvest was on September 22. All windfalls and 200 picked fruits per tree were sampled. The 2-pound dosage of xanthone with 8 ounces of *Genifilm A* and a quart of kerosene gave perfect film coverage on fruit and foliage. The fruit counts at harvest will be found in table 1.

During this experiment (as in Plot B in the same orchard) there occurred a sharp rise in temperature—from 90 to 103 degrees—for three days immediately following the May 18 application. On all xanthone-sprayed trees there occurred injury shown by a light leaf drop of the oldest leaves. The fruit also showed a slight russeting which persisted through harvest. Similar injury had been noted on apples in the Pacific Northwest from early applications. No further injury was noted on xanthone-sprayed trees from any subsequent spray. At the end of the season, however, the foliage of both the phenothiazine and xanthone-sprayed trees was definitely healthier in appearance than that on other trees in the plot, and the xanthone-sprayed fruit had a definitely higher color and a clean appearance.

All boxes of fruit from Plot A were marked as to treatment and the different lots were kept separated through commercial washing and into cold-storage. As late as April of the following year, when the fruit from storage received its final inspection, it was evident that the xanthone-sprayed fruit had kept better in storage than the other lots. It showed a higher pressure test with much less internal browning and scald. This factor of improved keeping quality with Newtown Pippins is under further investigation.

It was also observed at harvest time that the xanthone-sprayed fruit was much more free from woolly aphid infestation and leafhopper excrement than the other fruit.

Flath Orchard, 1942, Plot B. In an adjoining plot of Yellow Newton Pippins the following dosages of xanthone were tested on single trees with 4 replicates after a single lead arsenate calyx spray had been applied by the grower.

Xanthone 3 pounds, *Genifilm A* 8 ounces, kerosene 1 to 2 quarts

Table 1.—Comparative control of codling moth with xanthone at different strengths and combinations with lead arsenate and other materials. All plots received two calyx sprays of lead arsenate at 4 pounds except where noted. All spray combinations are based on 100-gallon units of spray.

No. of Applications	Cover Sprays Materials	Worms per 100 Fruits	
		Picked	Windfalls
	Rose Orchard, Bartlett Pears 1939		
5	Xanthone 2 lbs., Whale-oil soap 1 lb. and Hydrated lime 1 lb.	2.6	—
1	Lead arsenate 4 lbs. and		
4	Xanthone 2 lbs.	1.7	—
5	Lead Arsenate 4 lbs.	0.5	—
	Leary Orchard, Bartlett Pears 1942, Plot A		
3	Xanthone 1.5 lbs., *Genifilm A* 8 oz., Kerosene 2 quarts	0.3	0.9
3	Xanthone 3 lbs. *Genifilm A* 12 oz., Kerosene 2 quarts	0.04	0.3
3	Lead Arsenate 3 lbs., *Mixol* 3 oz.	0.04	1.0
	Leary Orchard, Bartlett Pears 1942, Plot B		
2	Phenothiazine (micronized) 2 lbs.	0.1	0.9
2	Xanthone 12 oz., *Genifilm A* 6 oz., Kerosene 1 quart	0.3	2.1
2	Lead Arsenate 3 lbs., *DN-111* 8 oz., *Mixol* 3 oz., Kerosene 1 quart	0.2	2.2
	Burbank Orchard, Red and Golden Delicious Apples 1940		
		(Red-Golden)	
3	Xanthone 2 lb., *Genispred* 6 oz., Kerosene 1 quart	1.3–8.4	—
3	Xanthone 3 lb., *Genispred* 6 oz., Kerosene 1 quart	0.5–3.8	—
3	Lead Arsenate 3 lb., *Multifilm* 5 oz., Kerosene 1 quart	0.5–2.9	—
	McKain Orchard, Winter Banana, Apples 1940		
2	Xanthone 2 lbs., *Genispred* 8 oz., Kerosene 1.5 pints	0.7	2.0
2	Cryolite 3 lbs., Lt. Oil 1 quart	1.7	1.0
2	Nicotine Bentonite 5 lbs., Lt. Oil 1 qt.	0.4	3.0
	Flath Orchard, Yellow Newtown Apples 1942, Plot A		
4	Xanthone 2 lbs., *Genifilm A* 8 oz., Kerosene 1 quart	4	9
4	Phenothiazine	2	8
4	Cryolite	7	12
4	Nicotine Bentonite 5 lb.	7	20
	Checks, no cover sprays	20	53
	Flath Orchard, Yellow Newtown Apples 1942, Plot B—One calyx spray only		
4	Xanthone 3 lbs., *Genifilm A* 8 oz., Kerosene 1 to 2 quarts	2	9
4	Xanthone 1.5 lbs., *Genifilm A* 4 to 8 oz., Kerosene 1 to 2 quarts.	6	20
4	Xanthone 12 oz., *Genifilm A* 4 oz., Kerosene 1 quart	10	38
1	Xanthone 2 lbs., Lt. Oil 2 quartz	—	—
	Check, no cover sprays	43	78

Xanthone 1.5 pounds, *Genifilm A* 4 to 8 ounces, kerosene 1 to 2 quarts

Xanthone 12 ounces, *Genifilm A* 4 ounces, kerosene 1 quart

Xanthone 2 pounds, *Genifilm A* 8 ounces, light summer oil 2 quarts

Checks, no cover sprays.

Applications in this plot were the same dates as in Plot A except that the xanthone at 2 pounds with oil emulsion was discontinued after May 18. All windfalls and 200 picked fruits from each tree were examined at harvest. Table 1 summarizes the fruit count.

In the treatment with xanthone at 2 pounds with oil emulsion, applied on May 18 only and followed by high temperature, the injury was most severe to both foliage and fruit which showed that the addition of an oil emulsion is unsafe. Most of the foliage dropped or was severely burned and all of the fruit was badly russeted. Analyses of 10 leaves and 10 fruits before and after several of the cover sprays showed deposits as indicated in table 2.

Though this shows a comparatively high deposit after each application, it also shows a very definite weathering in the intervals between applications. This might be accounted for in this region by the frequent heavy fogs during the nights and early mornings throughout the summer months when the leaves and fruits actually drip from the excess moisture. In spite of this loss of deposit the control in this

Table 2.—Residues of xanthone expressed as milligrams per square inch as found on fruit and foliage before and after the several treatments.

Time	Xanthone per 100 Gallons of Spray							
	12 ounces		1.5 pounds		2 pounds		3 pounds	
	A[1]	B	A	B	A	B	A	B
June 2								
Before second cover	12	10	43	19	41	—	86	—
After second cover	38	48	129	88	188	155	195	255
July 8								
Before third cover	2	2	17	37	—	—	42	138
After third cover	39	59	108	120	161	208	287	254
August 3								
Before fourth cover	4	11	29	22	30	14	73	75
After fourth cover	68	75	125	150	152	157	298	288

[1] A, Fruits; B, Leaves.

experiment was considered satisfactory.

Leary Orchard, 1942, Bartlett Pears, Plot A. In a randomized plot with five replicates, three cover sprays were applied, May 21, June 8 and July 13, following the usual two calyx sprays of lead arsenate The treatments were—

Lead arsenate 3 pounds, *Mixol* spreader 3 ounces and kerosene 1 quart;
DN-111 8 ounces, *Mixol* spreader 3 ounces;
Xanthone 1.5 pounds, *Genifilm A* 8 ounces and kerosene 2 quarts;
Xanthone 3 pounds, *Genifilm A* 12 ounces and kerosene 2 quarts.

Analyses showed residues from 1.5 pounds xanthone to be 146 mg. on fruit after the first cover; 25 mg. on fruit and 42 mg. on leaves just before second cover, 105 mg. on fruit and 101 mg. on leaves after the second cover; 1 mg. on fruit and 37 mg. on leaves just before third cover and 86 mg. on fruits and 94 mg. on leaves after third cover. From xanthone at 3 pounds the fruit showed 337 mg. after the first cover; just before the second cover, fruit 82 mg. and leaves 93 mg.; after second cover, fruit 268 mg. and leaves 165 mg.; just before third cover, fruit 29 mg. and leaves 72 mg.; and after the third cover, fruit 238 mg. and leaves 223 mg.

At the two pickings, July 24 and August 12, all the windfalls and 200 fruits per tree were sampled. The fruit counts are detailed in table 1.

Leary Orchard, Bartlett Pears, 1942, Plot B. In a randomized plot with five replicates, two cover sprays were applied, June 8 and July 13, following two calyx sprays of lead arsenate. The two cover sprays were as follows:

Micronized phenothiazine 2 pounds,
Xanthone 12 ounces with *Genifilm* 6 ounces and kerosene 1 quart,
Lead arsenate 3 pounds, *Mixol* spreader 3 ounces, kerosene 1 quart,
DN-111 8 ounces.

Analysis of the fruit from xanthone-sprayed trees after the first cover spray showed 36 milligrams per square inch, before the second cover no residue and after the second cover 24 milligrams of xanthone. The system of sampling fruit was the same as was used in plot A. (See table 1 for fruit counts.)

No spray injury on foliage occurred in either of the two plots, but mite injury was severe on both the lead arsenate-sprayed trees of plot A and the phenothiazine sprayed trees of plot B. In an attempt to measure this injury an accurate technique was developed to determine the percentage of total leaf area showing mite injury from the different treatments. This was done by taking 50 leaves from a definite position on the twigs from each tree in the treatment and by measuring the total area and the injured area of each sample. The samples were taken soon after the first picking date and before many leaves had dropped. Results from plot A showed 36 per cent area injured from lead arsenate, 3 per cent from the 3 pound dosage of xanthone and 1 per cent from *DN-111*-treated trees. From plot B the phenothiazine-treated trees showed 43 per cent injury, the lead arsenate *DN-111* sample no injury and the xanthone at 12-ounce dosage 9 per cent. The *DN-111* and xanthone-sprayed trees came through the season with practically no leaf injury from mite attack

whereas the phenothiazine- and arsenical-sprayed check trees were severely defoliated.

Due to the necessary curtailment of field work during the season of 1943, no extensive investigations were undertaken but xanthone was employed in three field tests in which all the applications were made by the growers. On Newtown Pippin apples at Watsonville a 40-tree plot was divided so that alternate rows received two and three applications of xanthone in the cover sprays following the usual two lead arsenate sprays. The cover sprays were applied June 23, July 29 and August 11. The fruit was harvested on September 22 and after careful examination and comparison with fruit sprayed with arsenical sprays from adjoining rows, a random sample was taken from each of the treatments and placed in cold storage at 36 degrees. Due to the unusual amount of sunshine this season the marked differences at harvest in coloration and pressure tests of the fruits were not as discernable as in the 1942 tests. The fruits placed in storage will be tested bimonthly for internal browning, scald, pressure test and soluble solids. It was very apparent that the fruit sprayed with xanthone was much cleaner in appearance than that sprayed with lead arsenate. This was due to the control of leafhopper and woolly aphid on the xanthone-sprayed trees. Codling moth control in the xanthone plot was definitely better than in the lead arsenate areas.

For the control of mites on Bartlett pear trees xanthone was applied in orchards at Kelseyville and at Ryde, by the growers. In the orchard at Kelseyville the area was divided into two parts. One part received one application xanthone 2 pounds and *Genifilm* 8 ounces July 1 to 5, and was to have received a second xanthone treatment (July 20 to 25) but was sprayed with *DN-111* by mistake. The other part received two applications of *DN-111* (0.5 pound per 100) on July 1 to 5 and on July 20 to 25. An inspection of the two plots on August 3 showed no leaf injury or leaf drop on the plot treated with xanthone, but the other plot showed considerable leaf injury and defoliation. In the orchard at Ryde two applications of xanthone were made, June 24 and July 24, on more than 50 trees in an area heavily infested with mites. The adjoining area received only the usual arsenical sprays. This block was under almost weekly observation until late October and showed only slight injury to a few leaves while the adjoining area was nearly half defoliated from mite injury.

MIXING XANTHONE.—Xanthone is supplied as a finely divided powder, usually in 6-pound bags. It is poorly wet by water and should not be added directly to the water in the spray tank. Field practice has shown that it can best be mixed by placing the required quantity of the chemical in a container and mixing it dry with the spreader to be used. It is then wet by the use of the spray gun with water under pressure until the materials are thoroughly wet or "slurried" when the kerosene is added and "slurried" again until the kerosene is thoroughly mixed with the wet solids. In this process, it is well to hold the disc of the spray gun against the bottom of the bucket and then, with a stirring motion of the gun, very gradually open the spray gun, thus avoiding blowing any of the materials out of the container. After mixing the materials should be added to the water in the spray tank with the agitator running. The mixture in the spray tank should show considerable flocculation of the solid materials. Xanthone is compatible with hormone sprays as applied in preharvest applications.

SPREADERS AND ADHESIVES FOR XANTHONE.—The spreader combination officially recommended for xanthone, whale oil soap and hydrated lime, either gave excessive run-off and low deposit or was incompatible under hard water conditions. Protein type spreaders such as blood albumen and *Fluxit* gave spotted and irregular deposits. The first film-type deposit was obtained by the use of a commercial product, *Genispred*, which later became known as *Genifilm A* and was to be used with kerosene. The use of an auxilliary agent called *Genifilm B* did not apparently increase the deposits and was discountinued. After many spot tests at different stages of development of the fruit of both pears and apples throughout the spray season, the following spreader recommendations were generally followed:

Xanthone 3 pounds, *Genifilm A* 8 ounces, Kerosene 2 quarts, or,

Xanthone 2 pounds, *Genifilm A* 6 ounces, kerosene 1 quart, or,

Xanthone 1 pound, *Genifilm A* 4 ounces and kerosene 1 quart, for each 100 gallons of spray mixture.

In general these combinations gave smooth film type deposits on both surfaces of the leaves and on the fruits. Increasing the amount of kerosene generally increases the deposit, but the use of the increased kerosene should be limited where temperatures are likely to be high following the applications. Due to the curtailment of supplies in the season of 1943, the *Colloidal 77* spreader was substituted for the *Genifilm A* fairly successfully though the amount was increased to 8 ounces as compared with 6 ounces of *Genifilm A*.

TOXICITY OF XANTHONE.—Xanthone is much less toxic to man than are the arsenates and its spray residues are considered non-injurious. No difficulty has been experienced in removing these residues by any type of commercial washer tested.

Not only are the young worms hatching from the eggs killed with Xanthone, but, according to Steiner & Summerland (1943) the material is a better ovicide than certain of the oil sprays used as ovicides. Xanthone was more effective against eggs deposited soon after the spray was applied whereas the oil-nicotine was effective only against the advanced stages of the eggs present when the spray was applied. These investigators also found xanthone to be most effective on eggs deposited on the foliage, where most of the eggs are found.

The apparent control of the Pacific mite on apple has been reported by Newcomer (1943) in the Pacific Northwest. The field data reported in this paper indicates that satisfactory prevention of injury from the two-spotted mite and the European red mite has been effected on Bartlett pear trees in this state. The rose leafhopper, *Empoa rosae*, commonly occurring on apple, has not damaged foliage or fruit on trees sprayed with xanthone and the picked fruit was noticeably clean. Less woolly apple aphid occurred in and on apple in the Watsonville area where xanthone had been used.

XANTHONE IN LATE COVER SPRAYS.—Xanthone used at the rate of 2 pounds per hundred gallons, following two arsenical sprays, apparently meets the requirements for a satisfactory substitute for lead arsenate under California conditions. It not only controls codling moth as well as, if not better than, lead arsenate in the cover sprays, but also prevents mite injury on pears and arsenical injury to the foliage of apples in the coastal areas. It also lessens the spray residue problem and apparently leaves the fruit and foliage in better condition than do the arsenical sprays. It will eliminate the use of oil emulsions in preharvest sprays and simplify the spray residue problem. Although the material shows comparatively poor weathering properties, it is apparent from past seasons' work that even when the summer applications are a month apart, the control has been satisfactory. Xanthone should not be combined with oil emulsions, nor should it be used too early on apples, especially during a period of comparatively warm days. No injury has been observed on Bartlett pears during these investigations.

Though the cost of xanthone is comparatively high at present, the advantages gained apparently justify its use. In comparison with an oil-lead arsenate program which is often used on Bartlett pears for the last two cover sprays, there is but little difference in cost. In the coastal area the elimination of arsenical injury to the foliage during the time the fruit is growing rapidly is important and may offset the additional cost of the xanthone.—1-11-43.

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ENSIGN F. F. BIBBY

F. F. Bibby, formerly Chief Pharmacist Mate in the U. S. Naval Hospital at Pensacola, Florida, has been commissioned as an Ensign in the Naval Reserve—H-V(S). He transferred, about March 20, to the Naval Medical School, Bethesda, Maryland, for a course in Malariology.

The Relative Effectiveness of Two Types of Arsenate of Lead Used to Control the Codling Moth

B. C. Dickinson and E. D. Witman

In 1938 some insecticide companies developed a new process for manufacturing arsenate of lead, whereby the physical properties of the component particles were altered from a so-called "amorphous" to a crystalline state. The claim was made that this new type of arsenate of lead was much more efficient for the control of the codling moth in the Pacific Northwest, in fact so much more so, that growers were already demanding this material in preference to the type of lead arsenate used in the past.

The literature offers no reference to the problem. Since converting of manufacturing equipment for the production of this type arsenate of lead involves considerable outlay, the Ohio State University Research Foundation authorized a laboratory research program to determine which of the two types of lead arsenate was the more efficient.

To start these studies, arrangements were made with Dr. Preebus of the Department of Electrical Engineering to have electron micrographs made of the two types of material. Dr. Preebus has kindly consented to have these included in this paper (Fig. 1 & 2). His interpretation of the micrographs are as follows: Both products are definitely crystalline in structure. Perhaps the striking difference is an increased aggregation of platelets in the case of the "crystalline lead" resulting in an apparent larger particle. Since he used a suspension of the material in a nitro-cellulose medium, he wasn't sure whether this coalescing of platelets was a natural phenomenon or rather a result of procedure in preparation

Table 1.—Results of laboratory tests of two types of arsenate of lead for the control of the codling moth larva.

Deposit per unit area 0.050 mg/cm²

Date	State		E	D	S	Total	χ^2	df	P
Jan. 17	Amorphous	No.	54	14	26	94			
		%	58	15	28		0.7130	2	.70
	Crystalline	No.	49	13	31	93			
		%	53	14	33				
Jan. 28	Amorphous	No.	125	50	87	262			
		%	48	19	33		0.5832	2	.80–.70
	Crystalline	No.	121	46	95	262			
		%	46	18	36				
Feb. 23	Amorphous	No.	116	28	53	197			
		%	59	14	27		4.1205	2	.20–.10
	Crystalline	No.	100	42	57	19			-
		%	50	21	29				
	Amorphous	Test for significance of difference between dates of performing tests.					6.4969	4	.20–.10
	Crystalline						4.6201	4	.50–.30

E—Entry
D—Dead
S—Stuck in tanglefoot

χ^2—chi-square
df—degrees of freedom
P—probability of occurrence

FIG. 1.—Electron micrograph No. 1. Showing structure of "amorphous" arsenate of lead. Unit of measurement—1 micron.

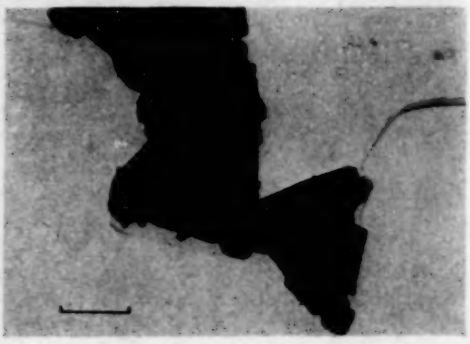

FIG. 2.—Electron micrograph No. 2. Showing structure of "crystalline" arsenate of lead. Unit of measurement—1 micron.

Table 2.—Results of laboratory tests of two types of arsenate of lead for the control of the codling moth larva.

Deposit per unit area 0.100 mg/cm²

DATE	STATE		E	D	S	TOTAL	χ^2	df	P
Dec. 20	Amorphous	No.	169	48	99	316	10.1238	2	.01
		%	54	15	31				
	Crystalline	No.	114	60	106	280			
		%	41	21	38				
Dec. 29	Amorphous	No.	98	45	82	225	5.6997	2	.10–.05
		%	44	20	36				
	Crystalline	No.	89	67	70	226			
		%	39	30	31				
Jan. 17	Amorphous	No.	37	13	41	91	6.3577	2	.05–.02
		%	41	14	45				
	Crystalline	No.	28	26	33	87			
		%	32	30	38				
Jan. 21	Amorphous	No.	44	35	44	123	10.1857	2	.01
		%	36	29	36				
	Crystalline	No.	26	58	48	132			
		%	20	44	36				
	Amorphous	Test for significance of difference between dates of performing tests.					20.9495	6	.01
	Crystalline						30.2848	6	.01

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χ^2—chi-square
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of the sample. It is also quite evident that the platelets produced by the aggregation of the crystalline particles were larger, a fact that probably had considerable influence on later field studies.

For laboratory toxicological studies, the

"apple slice method" developed by Harris & Waters (1943) was adopted. All larvae were secured from Yakima, Washington. A precision sprayer designed and constructed by Waters (1943) was used to apply all test materials. Jonathan apples were used for all tests. Tests of several concentrations were repeated three or more times during the course of the experiment, and it might be added that the two types of material were tested concurrently. All data were arranged in R×C Tables and analyzed statistically employing the statistic, chi-square.[1]

In past investigations the repellant potential of any test insecticide has been given relatively little weight. In this particular study, the technique adopted was of a nature that would allow the evaluation of this factor, as evidenced by the number of larvae becoming stuck in the ring of tanglefoot. Results appear in table 5.

DISCUSSION OF RESULTS.—The laboratory results presented in tables 1 to 5 indicate no significant difference between amorphous and crystalline lead arsenate when applied at low or high doses. At an intermediate dose (4 shots) the crystalline form appears to be superior, but since statistical analysis indicates that variations in test replications were not within the limits of experimental error, this would cast doubt on any apparent superiority.

Investigators on similar problems should give careful thought to the factor

Table 3.—Results of laboratory tests of two types of arsenate of lead for the control of the codling moth larva.

Deposit per unit area—0.200 mg/cm²

DATE	STATE		E	D	S	TOTAL	χ^2	df	P
Jan. 17	Amorphous	No.	20	40	25	85			
		%	24	47	29		0.7305	2	.98–.95
	Crystalline	No.	22	38	32	92			
		%	24	41	35				
Jan. 21	Amorphous	No.	27	49	46	122			
		%	22	40	38		6.5915	2	.05–.02
	Crystalline	No.	16	44	66	126			
		%	13	35	52				
Jan. 28	Amorphous	No.	46	68	54	168			
		%	27	41	32		8.1083	2	.02–.01
	Crystalline	No.	26	86	62	174			
		%	15	49	36				
Feb. 17	Amorphous	No.	34	49	74	157			
		%	22	31	47		2.8101	2	.30–.20
	Crystalline	No.	24	58	64	146			
		%	17	40	44				
	Amorphous	Test for significance of difference between dates of performing tests.					12.0321	6	.10–.05
	Crystalline						14.6409	6	.05–.02

E—Entry
D—Dead
S—stuck in tanglefoot

χ^2—chi-square
df—degrees of freedom
P—probability of occurrence

[1] Acknowledgement is made to Dr. E. L. Green, Professor of Biometry at Ohio State University who kindly advised the authors in analytical treatment of data.

Table 4.—Results of laboratory tests of two types of arsenate of lead for the control of the codling moth larva.

Deposit per unit area 0.400 mg/cm²

DATE	STATE		E	D	S	TOTAL	χ^2	df	P
Jan. 21	Amorphous	No.	8	64	51	123			
		%	65	52	42		2.5441	2	.30–.20
Jan. 21	Crystalline	No.	3	70	53	126			
		%	2	56	42				
Jan. 28	Amorphous	No.	9	32	35	76			
		%	12	42	46		10.0812	2	.01
	Crystalline	No.	3	54	25	82			
		%	4	66	30				
Feb. 6	Amorphous	No.	10	121	93	224			
		%	5	54	41		0.1108	2	.95–.90
	Crystalline	No.	11	115	91	217			
		%	5	53	42				
	Amorphous	Test for significance of difference between dates of performing tests.					6.7365	4	.20–.10
	Crystalline						5.4334	4	.30–.20

E—Entry
D—Dead
S—stuck in tanglefoot

χ^2—chi-square
df—degrees of freedom
P—probability of occurrence

of repellancy as presented in the content of table 5. In our search for a satisfactory substitute for lead arsenate in codling moth control, it is difficult to visualize a stomach poison as being the answer. These tests indicate that lead arsenate repells from 7 to 17 per cent of the larvae, depending on the dose, so possibly we should direct our studies along these lines.

SUMMARY AND CONCLUSION.—Data obtained as a result of a laboratory study to determine the relative efficiency of "amorphorus" and "crystalline" arsenate of lead are presented. Electron micrographs show both to be crystalline in structure. In the case of the "crystalline" there appears to be increased aggregation of the individual particles as to form a larger platelet. There is no consistent difference in the relative effectiveness of the two types for the control of the codling moth larva. Both exhibit considerable repellancy to larvae, a factor that should be given more consideration in future insecticidal investigations.—10-11-43.

Table 5.—Record of possible repellant effect of arsenate of lead to the first instar codling moth larva.

TREATMENT	DEPOSIT MG/CM²	NUMBER OF LARVAE SCORED	NUMBER STUCK IN TANGLE-FOOT	PER CENT STUCK
Amorphous	0.050	553	166	30
Crystalline	0.050	554	183	33
Amorphous	0.100	755	266	35
Crystalline	0.100	725	257	35
Amorphous	0.200	532	199	37
Crystalline	0.200	538	224	41
Amorphous	0.400	423	179	42
Crystalline	0.400	425	169	40
Untreated Check	—	972	226	23

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The Effect on Peach Trees of Ethylene Dichloride Used for Control of the Peachtree Borer

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Following the announcement of the favorable results obtained with ethylene dichloride emulsion for the control of the peachtree borer *Sanninoidea exitiosa* (Say) (Snapp & Thomson 1936) a large number of growers in many parts of the country adopted the method and used it very successfully. A survey in 1941 revealed that more than 80,000 gallons of ethylene dichloride went into the manufacture of the emulsion for peachtree borer control in 1940—enough to treat more than six million mature trees.

Although none of the experimental treatments applied by the senior author at the recommended dosage had caused injury to peach trees, a number of reports of tree injury, attributed to the ethylene dichloride treatment, were received during the season of 1940, chiefly from the Middle Applachian region. A careful investigation of the situation revealed the fact that much of the reported injury had been actually caused by winter conditions. In many cases there was just as much injury in orchards not receiving the ethylene dichloride treatment as there was in similar orchards nearby that had been treated. In a very few cases, however, the emulsion had been used at excessive strengths or in other ways not in accordance with current recommendations, and in such cases some of the injury reported was undoubtedly caused by the chemical.

To obtain more complete information on the danger of injury from the use of this chemical, and the conditions under which injury is most likely to occur, experiments were carried on from 1940 to 1942 at the Beltsville Research Center of the United States Department of Agriculture.[1] As the trees used were scheduled to be removed by the spring of 1941 or the spring of 1942, it was possible to test very strong emulsions of ethylene dichloride and even the undiluted chemical, which could not be tested in a grower's orchard on account of the danger of serious tree injury. It was also possible to make a type of examination for results which could not be resorted to on trees that were not to be removed. The various blocks of trees used were on several distinct soil types.

PREPARATION AND APPLICATION OF EMULSIONS.—The emulsions were prepared by the cold-stirred method, with a good grade of potash fish-oil soap as the emulsifier. The soap used was without an excess of caustic potash, and contained approximately 30 per cent of actual soap and 70 per cent of water. Unless otherwise indicated, each dose of the emulsion was poured on the soil around the base of the tree in such a way that the soil absorbed and held it around the tree at the ground line. There was no preparation of the soil before treatment, but several shovelfuls of soil were placed on the treated surface after the material was applied.

EXAMINATION FOR INJURY.—A preliminary examination for injury was usually made within a few weeks after the materials were applied. The final results were recorded in the spring shortly after blossom time. At this time the bark layers and cambium layer all around each tree from the root line up the trunk for as far as there was any evident injury were removed with a sharp hatchet. Some of the trees in each experiment were pulled out with a tractor so that the root systems could be carefully examined for injury.

DESCRIPTION OF INJURY TO PEACH TREES.—Severe ethylene dichloride injury consists in a killing of bark, cambium, and sometimes the underlying wood, which may extend as much as a foot above the ground line and some distance down the larger roots. The injured areas are more or less continuous, and there is no fine flecking of the bark or cambium such as occurs with injury from paradichlorobenzene. With less serious injury there may be smaller, separate, injured areas of various sizes and depths. Injury from ethylene dichloride is usually greater where there is a break in the bark layers. The chemical seems to enter a tree more readily at crown galls, borer wounds

[1] The writers acknowledge assistance in these experiments on the part of D. H. Scott, of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Mr. Scott made certain of the applications and assisted in the examinations.

mechanical wounds, broken lenticels, and bud scars.

In describing the injury that was observed in these experiments, the following terms have been used:

Very slight: Mere staining of the bark not extending into the cambium, or one or two very small injured areas (1 inch or less in diameter) extending into the cambium.

Slight: A number of small discolored spots in the bark layers, few or none of which extend into the cambium.

Moderate: Considerable areas of discolored bark, usually not extending far above or below the point where the chemical was applied, and extending into the cambium, and sometimes to a limited extent into the underlying wood.

Severe: Killing of bark, cambium, and wood tissues usually extending above ground and to a limited extent into the larger roots. Trees thus injured may recover, but will be seriously weakened.

Very severe: Killing of bark, cambium, and wood tissues, usually extending as much as a foot above the ground line and into the larger roots. Trees are so badly injured that they will almost certainly die.

EXPERIMENTS IN 1940 AND 1941.—Five-year-old Elberta trees on varietal root stocks and 9-year-old Belle trees were used for the work at Beltsville in the fall of 1940. In the 5-year-old orchard the tests included trees growing in the following types of soil: Silt loam of the Beltsville and Sassafras series, sandy loam of the Sassafras series, and loamy sand of the Beltsville series. The 9-year-old orchard was on loamy sand of the Beltsville or Evesboro series.

In most of the tests the material was used at a strength or in a quantity greater than one-half pint of 20 per cent emulsion, the dosage usually recommended for trees of these ages. At least 10 trees were used for each treatment, although in some cases only 8 or 9 were examined for injury. A row of 10 check trees was left between each 2 treated rows of 10 trees each in the 5-year-old orchard, and 3 check rows of 20 trees each were left on the sides of the 5 treated rows of 20 trees each in the 9-year-old orchard. In all, 640 trees were used for these experiments.

The materials were applied during the period September 28 to October 1. During the 2 weeks following the applications the temperatures were about normal for that time of the year, the minima ranging from 37° to 57° F. and the maxima from 56° to 80°. Rainfall of 0.83 inch occurred on October 2, and 0.42 inch on October 8. A preliminary examination for injury was made 16 to 19 days after the material was applied, a second examination was made January 6, 1941, and the final results were taken during the period April 25 to 29, 1941. The materials used and the injury observed are given in table 1.

The results of these experiments indicated that trees growing in the heavier soils are more likely to be injured by the ethylene dichloride treatment than those growing in lighter soils. On loamy sand soil, even the undiluted ethylene dichloride caused no injury to 9-year-old trees.

DIFFERENT METHODS OF APPLICATION IN WET SOIL LATE IN THE FALL.—The early directions for applying ethylene dichloride emulsion suggested that "the lower part of the trunk should receive some of the material during treatment" (Snapp 1938). Because of the danger of injury, the directions have been revised (Snapp 1940) to eliminate the portion that suggested applying part of the material directly to the tree trunks. More exact information seemed needed, however, to determine the effect of pouring the emulsion directly on the trunks of the trees. Experiments along this line were therefore begun on October 31, 1940. This was later than the usual date for the application of chemicals for peachtree borer control, and on that date the soil was very wet. The minimum temperatures ranged from 30° to 60° F., and the maximum from 42° to 71°. Rain totaling 1.36 inches fell on November 2, 0.82 inch on November 11, and 0.90 inch on November 14. The first examination for tree injury was made on January 6, 1941, and the final results were taken during the period April 26–29, 1941. The results of these experiments are given in table 2.

EXPERIMENTS IN 1941–42.—Further experiments were conducted in the fall of 1941 on 3-year-old seedling peach trees in Beltsville silt loam and Hyattsville silt

Table 1.—Results of experiments with different strengths and quantities of ethylene dichloride emulsion applied around peach trees growing in different soil types. Beltsville, Md., 1940–41.

Emulsion Applied		Injury	
Strength (Per cent)	Quantity (Pints)	Number of Trees	Degree of Injury
Experiments on Beltsville or Evesboro loamy sand (9-year-old trees)			
15	0.5	10	None
20	0.5	20	None
20	1	10	None
20	1.5	[1]	Moderate
		9	None
25	0.5	10	None
30	0.5	10	None
40	0.5	10	None
50	0.5	10	None
100[2]	0.5	10	None
No treatment	—	60	None
Experiments on Beltsville loamy sand (5-year-old trees)			
15	0.5	10	None
20	0.5	20	None
20	1	[1]	Very slight
		7	None
20	1.5	[2]	Slight
		6	None
25	0.5	10	None
30	0.5	10	None
40	0.5	10	None
50	0.5	10	None
100[2]	0.5	[4]	Severe
		4	Slight
		2	None
No treatment	—	60	None
Experiments on Sassafras silt loam to Sassafras sandy loam (5-year-old trees)			
15	0.5	10	None
20	0.5	20	None
20	1	[1]	Slight
		7	None
20	1.5	[1]	Severe
		1	Moderate
		2	Slight
		4	None
25	0.5	10	None
30	0.5	10	None
40	0.5	10	None
50	0.5	10	None
100[2]	0.5	[5]	Severe
		5	Moderate
No treatment	—	60	None
Experiments on Beltsville silt loam (5-year-old trees)			
15	0.0	10	None
20	0.5	20	None
20	1	[1][3]	Severe
		9	None
20	1.5	1	Severe
		5	Moderate
		4	None
25	0.5	10	None
30	0.5	[1]	Moderate
		9	None
40	0.5	10	None
50	0.5	[3]	Severe
		4	Moderate
		2	None
100[2]	0.5	[9]	Very severe
		1	Slight
No treatment	—	60	None

[1] A 7-year-old replant. [2] Undiluted (not emulsified).
[3] A very small tree about the size of a normal 2-year-old tree.

Table 2.—Results of experiments to determine the effect of pouring ethylene dichloride emulsion directly on the trunks of 5-year-old peach trees and on the soil around peach trees in wet soils late in the season. Beltsville, Md., 1940–41.

Emulsion Applied			Injury	
Strength (Per cent)	Quantity per Tree (Pints)	Manner of Application	Number of Trees	Degree of Injury
Experiments on Beltsville loamy sand				
20	0.5	On ground	3	None
		On trunk	[1]	Very slight
			4	None
30	0.5	On ground	6	None
		On trunk	[2]	Moderate
			5	None
50	0.5	On ground	1	Severe
		On trunk	2	Very severe
Experiments on Beltsville silt loam				
20	0.5	On ground	3	None
		On trunk	[2]	Very slight
			1	None
20	1	On ground	[2]	Severe
			2	Slight
		On trunk	4	Very severe
30	0.5	On ground	[1]	Moderate
			1	Very slight
		On trunk	3	Moderate
50	0.5	On ground	3	Severe
		On trunk	5	Very severe

loam, the type of soil in which the most injury to peach trees occurred the previous year. These tests included the application of the material in quantities and at strengths in excess of the recommended 0.5 pint of 15 per cent emulsion. Some of the applications were made to the tree trunks, and an effort was made to include a wide range of moisture and temperature conditions. Each treatment used at four different times was replicated three times, and each replicate consisted of three trees. Three check trees were left with each replicate of treated trees. In all, 187 trees were used for these experiments.

The first applications were made on October 3 and 4, when the soil was exceedingly hard and had only 3.9 per cent

Table 3.—Results of experiments with ethylene dichloride emulsion applied around peach trees under different soil, moisture, and temperature conditions. Beltsville, Md., 1941–42.

Emulsion Applied			Injury	
Strength (Per cent)	Quantity per Tree (Pints)	Manner of Application	Number of Trees	Degree of Injury
Experiments begun Oct. 3. Temperature high, soil very dry				
15	0.5	On ground	9	None
15	0.5	On trunk	2	Slight
			3	Very slight
			4	None
15	1	On ground	1	Very slight
			1	Slight
			7	None
25	0.5	On ground	1	Slight
			8	None
—	—	Untreated	9	None
Experiments begun Oct. 9. Temperature moderate, soil very moist				
15	0.5	On ground	9	None
15	0.5	On trunk	5	Slight
			2	Very slight
			2	None
15	1	On ground	9	None
25	0.5	On ground	9	None
—	—	Untreated	9	None
Experiments begun Nov. 12. Temperature low, soil moderately dry				
15	0.5	On ground	9	None
15	0.5	On trunk	3	Moderate
			3	Slight
			2	None
15	1	On ground	4	Slight
			5	None
25	0.5	On ground	2	Slight
			7	None
—	—	Untreated	9	None
Experiments begun Nov. 18. Temperature moderate, soil very wet				
15	0.5	On ground	9	None
15	0.5	On trunk	3	Severe
			1	Moderate
			3	Slight
			2	None
15	1	On ground	1	Severe
			2	Moderate
			3	Slight
			3	None
25	0.5	On ground	1	Moderate
			4	Slight
			4	None
25	0.5	On trunk	2	Very severe
			3	Severe
			2	Moderate
—	—	Untreated	9	None

of water in the top 4 inches and only 5.0 per cent of water in the top 12 inches. The wilting coefficient of the soil type and series used for these experiments is 8 per cent moisture. The maximum air temperatures on October 3 and 4, when the first applications were made, were 85° and 92° F., followed by even higher temperatures the next 3 days, after which the temperatures were more moderate. The soil temperatures were from 77° to 86° during this period.

As no rain had fallen by October 8, and none was immediately in sight or predicted, 15½ gallons of water were applied with a sprayer on the soil within a foot or two of the base of each of the 54 trees that were to be included in a second series of experiments. This brought the soil moisture content up to 17 per cent in the top 4 inches and 14 per cent in the top 12 inches, as compared with its maximum water-holding capacity of 20 per cent. The treatments were made on October 9, on which date the temperature ranged from a minimum of 55° to a maximum of 74° F. The soil temperature that day ranged from 59° to 68° F.

The third series of tests was made on November 12 when the soil was fairly dry and moderately hard. The soil had 10.3 per cent of water in the top 4 inches and 8.1 per cent of water in the top 12 inches, when these applications were made. The air temperature reached a maximum of 49° F. that day, and the soil temperature 48°. The air temperatures the following week ranged from minima of 28° to 44° to maxima of 59° to 70°.

As no rain fell between November 6 and 17, water was applied to the soil around the base of the trees as had been done for the second applications, and the fourth experiments were made on November 18 when, as a result of the watering, the soil had 17 per cent of water in the top 4 inches and 18 per cent water in the top 12 inches —nearly its maximum water-holding capacity. On the day the treatments were applied the air temperature ranged from 37° to 70° F. and the soil temperature from 45° to 52°. During the following two weeks the temperature dropped below freezing three times—to 23° on November 23, 24° on November 26, and 26° on November 27. The maximum temperatures ranged from 45° to 77°. No rain fell during that period.

A preliminary examination for tree injury was made on November 12, and the final results were taken on April 22, 23, and 24, 1942. The results of these experiments are given in table 3.

The most serious injury resulted from 0.5 pint of 25 per cent ethylene dichloride emulsion (two-thirds stronger than recommended) poured on the trunk late in the fall when the heavy soil was very wet. Two of the most severely injured trees would probably have been killed by the treatment if they had been allowed to remain in place. Some injury rresulted when the liquid was applied to the ground at the same dosage and under the same conditions. These results are in line with those

obtained by Worthley & Steiner (1942), who reported that the most serious injury by ethylene dichloride emulsion occurred following the application of treatments in November to very wet, cold soil. Earlier treatments by these workers had resulted in negligible injury.

ETHYLENE DICHLORIDE TREATMENT AND WINTER INJURY.—There had been a possibility that the experiments might give information on any relation existing between the ethylene dichloride treatment and winter injury, but the work at Beltsville threw no light on this phase of the problem, since winter injury did not develop during the course of the experiments.

DISCUSSION.—No injury whatever resulted from the application of ethylene dichloride emulsion in accordance with current recommendations, even on 3-year-old trees, which are sometimes severely injured by the paradichlorobenzene treatment. However, the fact that injury occurred when the material was applied directly to the trunks of the trees, and when the emulsions were used at twice or more the standard strength or quantity, emphasizes the need for care in mixing and applying the insecticide. Any cracks in the ground around or extending out from the tree trunk should be filled with soil before the ethylene dichloride is applied so that undue concentration of the material on any part of the root system may be avoided. The liquid should not be poured or sprayed on the trunk, but should be applied to the soil around the base of the tree in such a way that the soil will absorb and hold it around the tree at the ground line. The stock emulsion should be well made and inspected before use to see that it has not broken down, and should be thoroughly stirred before any is taken from the container for dilution. The diluted emulsion should likewise be agitated before each dose is withdrawn for use around the tree.

SUMMARY AND CONCLUSIONS.—No injury resulted from the treatment of peach trees in several different soils under a wide range of conditions when ethylene dichloride was used at the recommended quantity and strength (for mature trees, 0.5 pint of 20 per cent emulsion; for 3-year-old trees, 0.5 pint of 15 per cent emulsion) and when it was applied in the currently approved manner, namely, on the soil around the base of the tree in such a way that none of the material touches the trunk directly. The moisture content of the soil had no effect on injury when the emulsion was applied early in October, nor did injury increase when the application was made to moderately dry soil in mid-November. Injury did occur, however, when the emulsion was tested at strengths or quantities higher than recommended when it was applied in water-logged, heavy soil late in the fall when temperatures were low, and injury was more severe in the heavy soils. Applying the emulsion directly to the trunks of the trees increased the injury.—11-1-43.

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DR. ROGER SMITH WITH WAR MANPOWER COMMISSION

Dr. Roger C. Smith, Head of the Department of Entomology at the Kansas State College, Manhattan, Kansas, has been granted leave of absence beginning February 1, 1944, to accept a position in the War Manpower Commission in Washington, D. C., as Professional Allocations Specialist for the Biological and Agricultural Sciences. Dr. R. L. Parker has been designated Acting Head of the Department and Professor George A. Dean, who has been retired from college administrative duties, will carry on the duties of State Entomologist during the leave of absence of Dr. Smith.

Determination of Oil Deposit on Citrus Leaves by the Steam-Distillation Method[1,2,3]

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In a previous publication (Gunther & Ebeling 1942), the construction and operation of a multiple apparatus for the determination, by steam distillation, of kerosene oil deposit on citrus leaves was discussed in some detail. This method involved the selective chemical disintegration of the leaf cells, accompanied by a superheated steam distillation of the stable oils present. Complete disintegration of the leaf cells, with consequent liberation of any spray oil (kerosene) that had penetrated those cells, was secured by the use of an aqueous solution ("reagent") of sulfuric acid, nitric acid, and aluminum sulfate. An average recovery of 98.4 per cent of the kerosene applied was demonstrated, and the coefficient of variation of the method in a field test was found to be 0.0467, or a variation of 4.67 per cent.

The present investigation was undertaken in an attempt to adapt this new method to the recovery of spray oils more viscous, or "heavier," than kerosene, and this paper presents the results obtained with six grades of oil, ranging from mineral seal oil to the heaviest grade of summer spray oil used on citrus trees in California. The method has been standardized for these oils and has proved to be rapid, accurate, and reproducible, and apparently independent of the extent to which penetration of oil into the plant tissue has occurred.

THE SPRAY OILS USED IN THIS INVESTIGATION.—Some of the characteristic physical properties of the six grades of oil used in this investigation are shown in table 1. These oils were chosen as being representative of all California proprietary spray oils for use on citrus trees.

APPARATUS FOR THIS METHOD.—Since the design and construction of the necessary apparatus were fully discussed in the first paper of the series (Gunther & Ebeling 1942), no description of them is necessary here. No modifications in the original apparatus were required for the present adaptation to the determination of the deposit of the spray oils mentioned above.

LEAF DECOMPOSITION.—The aqueous "reagent" developed for determinations of kerosene deposit was not satisfactory when applied to oils "heavier" than kerosene, even if the time of distillation was increased materially. Representative distillation yields, from known quantities of the various spray oils applied to average-sized, mature lemon leaves by means of a calibrated microburet, are collated in table 2 to show the inefficiency of this mixture of acids when used with oils other than kerosene. Each sample, consisting of 50 leaves plus added oil, was allowed to stand at room temperature for 1 hour before analysis, in order to insure some inter- and intracellular penetration by the

Table 1.—Certain pertinent characteristic physical properties of the spray oils employed in this investigation.

GRADE OF OIL	SPECIFIC GRAVITY (25°/4)	VISCOSITY (SECONDS SAYBOLT)	TEMPERATURES (DEGREES F.) AT WHICH DISTILLATION WAS—				
			10%	25%	50%	75%	90%
Mineral seal	0.8739	45	527.0	538.5	559.0	585.0	614.0
Light	0.8739	57	562.5	584.0	613.0	647.5	678.5
Light-medium	0.8766	67	585.5	605.0	629.0	662.5	698.5
Medium	0.8861	80	585.0	613.5	646.5	681.0	715.5
Heavy-medium	0.8878	85	611.0	627.5	651.0	678.0	705.5
Heavy	0.8872	95	627.5	640.5	660.5	685.0	709.5

[1] Paper No. 505, University of California Citrus Experiment Station, Riverside, California.

[2] This paper is the second of a series of studies in the general field of oil-deposit determinations. For the first paper, see Gunther & Ebeling (1942).

[3] A grant from the Irvington Varnish and Insulator Company, Irvington, New Jersey, to the University of California Citrus Experiment Station made possible a research program in which this method of oil-deposit determination was an incidental development.

[4] Principal Laboratory Assistant in the Experiment Station.

[5] Principal Laboratory Technician in the Experiment Station.

oil before distillation. The first four runs (samples 1 to 4) were of 4-hour duration, and the second four (samples 5 to 8) were of 2-hour duration.

Kerosene steam-distills very rapidly; the sulfonic acids produced by the reagent therefore have little chance to emulsify tightly any kerosene present. On the other hand, the "heavier" spray oils require a higher temperature for the initiation of steam distillation, and it is very probable that this slight temperature increment is sufficient to induce tight emulsification. In the absence of plant material, however, a quantity of the light-medium-grade spray oil steam-distilled completely with this reagent; the so-called "heavy ends" of the oil had no effect on the yield, for they, too, steam-distilled, as demonstrated by this 100 per cent recovery of the oil, with a distillation period of 2 hours.

The foregoing facts indicated that a spray oil could be steam-distilled quantitatively, but that the sulfuric acid reagent was not satisfactory in the presence of plant material. As mentioned above, it seemed probable that the failure of this reagent was due either to emulsification or to induced sorption phenomena or both although neither possibility was investigated extensively. Since emulsification holdback seemed the more logical and more easily remediable premise, certain modifications in the aqueous reagent were made in an attempt to antagonize any emulsification present.

It was thought, for example, that a rapid rate of heating might steam-distill the petroleum oils before the reagent had liberated an appreciable quantity of the emulsifying sulfonic acids from the leaf tissues. Accordingly, four oil-sprayed samples (samples 5 to 8, table 2) containing 50 leaves each were first heated very rapidly until the leaves had been digested by the reagent, and then very slowly until the oil ceased steam-distilling. Another four samples (samples 1–4, table 2) were heated in the reverse order, first slowly and then rapidly. The yields of recovered spray oil were very poor for all eight samples, as shown in table 2. The recovery of oil was less when intense heat was applied at the beginning of the distillation than when it was applied at the middle of the distillation. Excessive foaming always resulted when high heat was applied before the leaves had partially digested.

Table 2.—Distillation yields of spray oils recovered from lemon leaves, showing inefficiency of aqueous "reagent"[1] when used with oils other than kerosene, in the presence of plant material.

Sample[2]	Grade of Oil[3]	Reagent Used Milliliters	Oil	
			Milliliters Added	Per Cent Recovered[4]
1	Light-medium	300	1.46	61.2
2	Light-medium	300	1.44	69.4
3	Heavy-medium	300	1.28	54.1
4	Heavy-medium	300	1.41	48.0
5	Light-medium	400	1.62	52.4
6	Light-medium	400	1.83	50.2
7	Heavy-medium	400	1.15	46.1
8	Heavy-medium	400	2.28	33.3
9	Kerosene[5]	600	3.31	98.2

[1] This "reagent," developed for use in kerosene-deposit determinations, contained 300 ml. of technical concentrated sulfuric acid, 11 ml. of concentrated nitric acid, and 4.5 grams of technical aluminum sulfate, made up to 1 liter with distilled water. (For further details, see Gunther & Ebeling 1942.)

[2] Each sample contained 50 lemon leaves.

[3] For specifications of the light- and heavy-medium oils, see table 1.

[4] Value reported is corrected for sulfonation loss.

[5] Included for purposes of comparison. These data were selected from the first paper of this series on oil deposit (Gunther & Ebeling 1942).

Unnecessarily great emulsification, evidenced in part by this excessive foaming, occasionally may be eliminated if the foam is prevented from forming. Various waxes, alcohols, and commercial antifoaming agents were tested without success. Most of these agents steam-distilled before they had a chance to act. In addition, one of the units on the apparatus was modified so that a high-pressure jet of prewarmed air (100° C.) impinged on the surface of the foam in the flask. This procedure also failed to improve the yield of oil, although the foaming was suppressed considerably.

Other acids and other combinations of acids were tested in an effort to overcome this retention of petroleum oil. The most promising of all the trials were those in which phosphoric acid was utilized, on the assumption that this acid would not liberate emulsifying agents from organic matter so readily as would sulfuric acid. Various grades and dilutions of this acid were used, the most satisfactory results being obtained with sirupy (85 per cent) phosphoric acid solution in a dilution of 1:1, yielding a phosphoric acid solution of approximately 43 per cent. The data supporting this conclusion are presented in table 3.

Objectionably heavy foaming was also encountered when aqueous phosphoric acid was employed, even though the re-

Table 3.—Representative steam distillations of samples treated with light-medium spray oil, to determine the efficiency of various concentrations of sirupy (85 per cent) phosphoric acid in effecting decomposition of leaf tissue.

	Phosphoric Acid		Oil	
Sample[1]	Percentage Concentration	Milliliters Used	Milliliters Added	Per Cent Recovered[2]
1	30	300	2.00	80.1
2	30	300	2.00	80.0
3	43	300	2.50	89.2
4	43	300	2.50	88.8
5	50	180	2.00	73.0
6	50	180	2.00	79.5
7	50	450	2.80	88.6
8	57	300	2.00	87.0
9	57	300	2.00	87.0

[1] Each sample contained 50 lemon leaves and was steam-distilled for 2 to 2.5 hours.
[2] Value reported is corrected for sulfonation loss.

covery of oil had become very respectable and consistent. Again, a number of antifoaming agents were used, but without appreciable success. These included compressed air, caprylic and octyl alcohols, butyric, oxalic, and stearic acids, ethyl sulfate, *Cardolite 627*,[1] glycerol, rosin, *n*-butyl phthalate, boric acid, aluminum oxide, and potassium alum. No foam inhibitor was found which would suppress the foam or increase the yield of oil sufficiently to warrant its use in the analytical procedure.

Effect of Fuel-Gas Pressure.—Any pronounced fluctuation in the line pressure of the fuel gas used by the apparatus would influence the rate of heat application and thus the efficiency of the current distillation, in accordance with the findings mentioned previously in connection with table 2. In order to test the extent of this effect, an open-tube manometer containing dyed alcohol was built into the feeder gas line where it entered the apparatus. This manometer was calibrated in terms of inches of alcohol, with atmospheric pressure reading zero inches. A total of twenty-three distillations, using three different grades of oil, indicated that the normal laboratory fluctuations in gas pressure had no demonstrable effect on the efficiency of the method, as shown by the representative data in table 4.

Analytical Procedure.—The general details of operation and procedure are to be found in the first paper of this series (Gunther & Ebeling 1942). Only those operations pertinent to the present developments will be discussed here.

In order to determine the efficiency of the method, from 0.25 to 3.5 ml. of the oil under consideration was dispensed from a calibrated microburet into the 2-liter distilling flask containing the sample of 50 lemon leaves. This range of volume of oil was shown by preliminary experiments to include very generous maxima and minima values for the quantities of oil per sample of 50 leaves (average total area about 5500 cm.^{2}) to be expected in field practice. The flask was stoppered tightly and shaken thoroughly; it was then allowed to stand at room temperature for about 2 hours to insure some penetration into the leaf tissues.

After 300 ml. of the dilute (1:1) phosphoric acid reagent had been introduced into the flask, the sample was steam-distilled with superheated steam for 2 hours. Several small portions of acetone were used to wash out the condenser at the completion of the distillation, and the acetone was salted out of the oil in the receiver with several small portions of water. Readings were then made of oil+waxes in the receiver. After the water in the receiver had been drained off, the oil+wax residue was transferred quantitatively with petroleum ether (30 to 60° C.) into Babcock milk-test bottles and sulfonated at 65 to 70° C. in order to determine the unsulfonated (Pearce *et al.* 1942) residue of the distilled oil. Checks were run on the sulfonation value for each of the six oils tested, and the loss of oil for each sample distilled and sulfonated was corrected accordingly.

Table 4.—Effect of fluctuations in fuel-gas pressure upon the efficiency of the steam-distillation method.[1]

Grade of Oil[2]	Milliliters of Oil Added	Per Cent of Oil Recovered[3]	Manometer Reading Inches[4]
Mineral seal	3.53	95.6	10.3
Mineral seal	2.03	96.5	11.1
Mineral seal	1.03	96.4	10.4
Light	3.53	93.4	11.9
Light	2.53	93.6	10.1
Light-medium	2.03	92.0	10.1
Light-medium	0.25	91.9	10.7

[1] Each sample contained 50 lemon leaves and was steam-distilled for 2 to 2.5 hours.
[2] For specifications of these oils, see table 1.
[3] Value reported is corrected for sulfonation loss.
[4] An open-tube manometer containing dyed alcohol was employed. Atmospheric pressure read zero inches on this instrument.

[1] A condensation polymer of formaldehyde and cardanol, the phenolic material expressed from the husk of the cashew nut, prepared and marketed by the Irvington Varnish and Insulator Company, Irvington, New Jersey.

When the volume of oil+waxes, as read directly in the receiver, was plotted against the volume of oil after sulfonation the straight lines shown in figure 1 were obtained. Each plot represents one of the six oils used in this investigation. This graph thus shows that sulfonation is unnecessary as a means of determining the unsulfonated residues of the oils after the

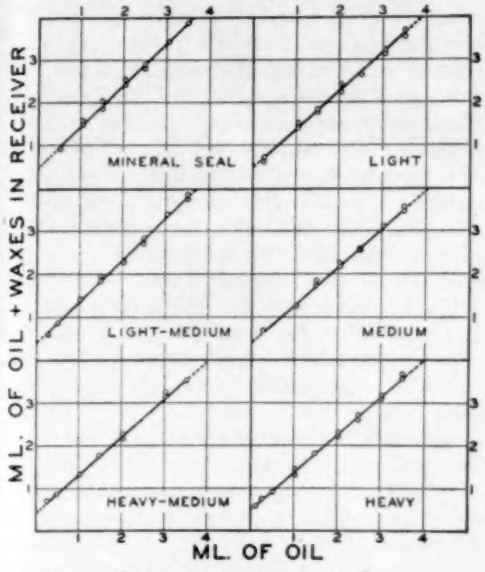

FIG. 1.—Relationships between volumes of representative light and standard grades of citrus spray oils and waxes and volumes of unsulfonated residue in distillate.

apparatus has been check-calibrated with known samples. In fact, in order to convert the volume of oil+waxes in the receiver into volume of unsulfonated residue, it is necessary only to multiply the former figure by the reciprocal of the slope (co-tangent of the angle formed) of the appropriate straight line. By reconstructing the graph, values of oil+waxes may be translated directly into values of oil corrected for sulfonation loss, although the differences usually are slight for such small volumes of oil.

ACCURACY OF THE METHOD.—In table 5 are shown the results of 7 representative runs with each grade of spray oil, as determined with a four-unit apparatus. These data were selected at random from the results obtained from over 100 calibration runs. The mean percentage recoveries for the mineral seal and light-grade oils were about the same (94.7 and 92.4 per cent, respectively). Furthermore, the percentage recoveries for the light-medium, medium, heavy-medium, and heavy-grade oils were approximately the same, although somewhat lower than for the two lighter-grade oils. These facts indicate that the oils which contained a small per-

Table 5.—Results of calibration steam distillations of samples treated with the six grades of spray oil, to show the accuracy of the steam-distillation method.[1]

Grade of Oil[2]	Oil Added, Milliliters	Oil Recovered	
		Milliliters	Per Cent[3]
Mineral seal	0.50	0.44	90.2
	1.03	0.96	95.2
	1.03	0.97	96.4
	1.53	1.42	94.6
	2.03	1.92	96.5
	2.53	2.34	94.4
	3.53	3.30	95.6
Mean			94.7
Standard deviation			2.26
Light	0.25	0.22	88.3
	1.03	0.94	93.3
	1.53	1.39	92.9
	2.03	1.83	91.9
	2.53	2.32	93.6
	3.03	2.77	93.3
	3.53	3.23	93.4
Mean			92.4
Standard deviation			2.04
Light-medium	0.50	0.41	84.3
	1.03	0.86	85.6
	1.53	1.28	85.7
	1.53	1.31	87.3
	2.03	1.69	84.9
	2.53	2.08	84.1
	3.53	3.08	88.1
Mean			85.7
Standard deviation			1.75
Medium	0.25	0.22	88.4
	1.03	0.88	87.6
	1.53	1.31	87.8
	2.03	1.77	89.4
	2.53	2.19	88.4
	3.03	2.60	87.7
	3.53	3.06	88.6
Mean			88.3
Standard deviation			0.67
Heavy-medium	0.50	0.45	92.7
	1.03	0.88	87.7
	1.53	1.31	87.9
	2.03	1.74	87.8
	2.53	2.22	89.6
	3.03	2.63	89.0
	3.53	3.19	92.4
Mean			89.6
Standard deviation			2.14
Heavy	0.50	0.42	85.1
	1.03	0.86	85.3
	1.53	1.30	86.8
	2.03	1.71	85.9
	2.53	2.16	87.4
	3.03	2.56	86.4
	3.53	3.02	87.4
Mean			86.3
Standard deviation			0.94

[1] Each sample contained 50 lemon leaves and was steam-distilled for 2 to 2.5 hours.
[2] For specifications of these oils, see table 1.
[3] Value reported is corrected for sulfonation loss.

centage of "heavy ends" steam-distilled at the same rate, although their viscosities were different, and that those oils which contained a considerable amount of "heavy ends," regardless of the proportion of "heavy ends," steam-distilled at the same rate. No explanation for this interesting phenomenon is offered at this time.

The standard deviation, within a set of percentage recoveries, for a given grade of oil, may be obtained from table 5, also. It has been the experience of the workers at this experiment station that an average standard deviation of 1.63 per cent, as found in this method, indicates a low variation in methods dealing with the removal of spray residues in field practice. The maximum variation from the mean was 4.5 per cent and was found in the determinations with the mineral seal oil.

MANIPULATIVE SUGGESTIONS.—The distillation period of 2 hours is essential for uniformity of results with these spray oils. Very little "waxing" occurs within this period, although traces of wax may appear within the last few minutes of distillation. It is suggested that the appearance of these waxes should not be taken as a criterion of the nearness to completion of the distillation, as with kerosene, for the sample of leaves will "wax" only occasionally with the spray oils. In order to facilitate the reading of the buret tube within the receiver assembly, it was, however, found convenient to place a few drops of a 2 per cent acetone solution of the oil-soluble dye Sudan II into this tube before beginning distillation. This dye imparted an intense red color to the oil layer.

SUMMARY.—Directions are given for the adaptation of a steam-distillation method of determining oil deposit to the quantitative determination of deposits of two of the ligher grades and four of the standard grades of spray oils, on lemon leaves. The major difference between this adaptation and the kerosene adaptation previously described lies in the use of dilute phosphoric acid, instead of an aqueous solution of sulfuric acid, nitric acid, and aluminum sulfate, as the decomposition medium. Data are presented to justify the alterations adopted for this expanded utility, and to indicate the high degree of reproducibility and efficiency of this new adaptation.

The results from 42 representative calibration runs (7 runs for each of the six oils studied) indicate an average standard deviation of 1.63 per cent for these oils.—11-12-43.

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CAPTAIN R. N. JEFFERSON

Captain Jefferson writes from the Aleutians where he has finally been located after varied experience in training camps in this country. Apparently Captain Jefferson is not over-optimistic about the duration of the war as he sends in payment for Journal subscription for three years in advance.

LIEUTENANT KENNETH L. KNIGHT, USNR

Lieutenant Knight writes from 121 Wesley St., Wheaton Ill. He states that he has just returned from the South Pacific Area (not the Southwest Pacific) where he has been Area Entomologist for the Malaria and Epidemic Control Unit of the South Pacific. He has been recalled to this country for new orders and new duty at Washington.

Factors Influencing Protective Stupefaction of the California Red Scale with HCN

HAROLD R. YUST, HOWARD D. NELSON, and R. L. BUSBEY, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In field fumigation with hydrocyanic acid the California red scale, *Aonidiella aurantii* (Mask.), is frequently exposed to low concentrations of cyanide prior to the regular fumigation. These low concentrations result from leakage of gas through the tent in the fumigation of trees nearby and sometimes reduce the kill resulting from exposure to the regular fumigations. This phenomenon was first observed by Gray & Kirkpatrick (1929) and was called protective stupefaction. It is a very important factor in field fumigation because the scales in all the exposures following the first are quite generally exposed to the gas escaping through the tent. Yust *et al.* (1942) have previously reported studies on protective stupefaction of resistant and nonresistant scales. The present paper covers further investigations on protective stupefaction of resistant scales in the second molt and mature female stages with particular reference to the interrelations of temperature, prefumigation dosage, and interval between prefumigation and final fumigation.

Fumigation tests were made in the laboratory under controlled conditions. Scales were prefumigated or exposed to a relatively low concentration of gas prior to exposure to a normally high concentration, and the mortality was compared with that from only a normally high concentration. The methods and apparatus used were the same as those described by Yust & Howard (1943). Resistant scales on lemon fruits were reared in the laboratory or obtained in the field. Fifty female insects in one or two stages were marked on each fruit prior to fumigation. The scales were preconditioned and postconditioned for 4 hours at the treatment temperature. Unless otherwise stated, each mortality record was based on 1200 insects. No corrections were applied for natural mortality, which was very low.

RESULTS.—It was shown by Yust *et al.* (1942) that the prefumigation concentration influenced the protective stupefaction. To determine the minimum concentration producing protective stupefaction, mature female scales were prefumigated at four concentrations for 10 minutes. The final fumigation, with a constant concentration of 0.8 mg. per liter for 40 minutes at 68° F., followed immediately after the prefumigation. The fumigations were duplicated on 2 days. The scales treated on one day had been reared in a lathhouse at temperatures comparable to those in the field and those on the other day were obtained in the field. The prefumigations prior to the final treatment were with concentrations of 0.010, 0.025, 0.050, and 0.10 mg. per liter and the corresponding mortalities were 91.8, 65.9, 64.0 and 66.3 per cent. The mortalities with only the final fumigation, with only a prefumigation of 0.10 mg. per liter for 10 minutes, and without either prefumigation or final fumigation, were 96.0, 6.3, and 2.3 per cent respectively. Maximum protection was obtained with a minimum concentration of 0.025 mg. per liter for 10 minutes.

In the above test mature female scales were also prefumigated with a concentration of 0.025 mg. per liter for periods of 2, 4, 7, and 10 minutes followed immediately with a constant concentration of 0.8 mg. per liter for 40 minutes at 68° F. The corresponding mortalities were 95.0, 94.2, 72.6, and 65.9 per cent. The mortality with only the final fumigation was 96.0 per cent. Under these conditions no appreciable protective stupefaction occurred in 2 or 4 minutes.

To determine the mortalities resulting from relatively long exposures to prefumigation concentrations, mature female scales reared at 77° F. were fumigated for 4 hours at 68° F. with four concentrations that previous experiments showed produced protective stupefaction. The scales were not exposed to further fumigation. The concentrations were 0.009, 0.025, 0.041, and 0.140 mg. per liter and the corresponding mortalities were 6.9 ± 1.5, 23.3 ± 2.0, 24.8 ± 2.2, and 41.2 ± 2.5 per cent.

The influence of temperature on protective stupefaction was observed in fumigations of scales in the second molt reared in the lathhouse at temperatures comparable to those in the field and in

fumigations of mature female scales obtained in the field. The fumigations were at four temperatures with and without prefumigation immediately prior to the final fumigation. With the second molt the concentration was 0.14 mg. per liter at the start of the prefumigation and decreased to 0.03 mg. at the end of 45 minutes, and with mature females the concentration was 0.04 mg. per liter at the start and 0.01 mg. at the end. Each mortality is based on 600 insects. The final concentrations and the mortalities at each of the temperatures are given in table 1.

Table 1.—Mortality of the California red scale resulting from fumigations at four temperatures with and without prefumigation immediately prior to final fumigation.

Temperature °F.	Final Concentration, Mg. per Liter		Mortality, Per Cent	
	Range	Average	Not Prefumigated	Prefumigated
	Scales in Second Molt			
50	2.75–0.17	1.11	99.2±0.4	92.3±2.0
59	2.73– .12	.94	96.5±0.7	75.8±2.2
68	2.72– .08	.90	92.7±1.5	66.7±4.5
77	2.77– .09	.89	85.2±2.4	78.3±3.3
	Mature Female			
50	2.29– .09	.68	100	51.8±3.0
59	2.28– .09	.68	100	47.3±3.6
68	2.31– .09	.69	99.5±0.2	60.5±2.6
77	2.30– .09	.68	98.5±0.6	67.7±1.6

At all temperatures the mortalities of scales subjected to prefumigation were less than the mortalities of those not pefumigated. It was shown by Yust *et al.* (1942) that without prefumigation the kill of mature female scales and scales in the second molt increased as the temperature was lowered. With prefumigation this relationship does not exist.

To determine the effects of different factors on protective stupefaction, a series of laboratory fumigations were carried out under conditions simulating those in the field. Mature female scales and scales in the second molt, obtained in the field and both stages occurring on the same fruits, were fumigated at four temperatures with several prefumigation concentrations. Some of the scales were prefumigated immediately prior to the final fumigation and others 2 hours earlier. This 2-hour interval between the prefumigation and the final fumigation was selected because Yust *et al.* had previously shown (1942) that, under certain conditions, it affected the kill. Decreasing prefumigation concentrations were used that are likely to be encountered as drift-gas concentrations in the field. The concentrations in the final fumigations at 50° and 59° F. ranged from 2.40 mg. per liter at the beginning to 0.11 mg. at the end; at 68° F. they ranged from 2.8 mg. per liter at the beginning to 0.12 mg. at the end; and at 77° F., from 3.24 mg. at the beginning to 0.16 mg. at the end at both the prefumigation and the final fumigation the exposures were 45 minutes. Each mortality figure is based on 1200 insects, except in the treatments at 77° F., in which each is based on 600 insects. The results are summarized in table 2.

In the second molt the higher prefumigation concentration immediately preceding the final exposure produced more protective stupefaction at all four temperatures than the lower concentration, but the lower concentration produced some protective stupefaction at all the temperatures except possibly 77° F. With mature female scales in the treatment at 50° F. more stupefaction resulted from the lower prefumigation concentration but at 77° F. more stupefaction resulted from the higher prefumigation concentration. It is thus evident that a higher prefumigation concentration is required to stupefy both stages as the temperature increases. It is also evident that more cyanide is required to stupefy scales in the second molt than mature female scales. With the low prefumigation concentration at 50° F. the mortality of scales in the second molt was higher than that of the mature female scales because of the differential stupefaction of the two stages. This may explain the variation in the relative susceptibility of the two stages that has been observed in the field.

Considerable protective stupefaction was usually lost when a 2-hour interval elapsed between the prefumigation and the final fumigation. In general, the mature female scales remained stupefied longer than the scales in the second molt when compared with their respective checks. The period over which protective stupefaction continued was influenced by the prefumigation concentration and the temperature. In the second molt with the higher prefumigation concentration, protective stupefaction was lost in 2 hours but with the lower this was not always the

case. The protective stupefaction of the mature female scales decreased after 2 hours as the treatment temperature increased, and at 77° F. the kill of those stupefied 2 hours earlier was higher than that of those not stupefied.

Prefumigation alone usually was not toxic to the scales in the second molt but generally produced some mortality of mature female scales. It is thus evident that a concentration may be slightly toxic and still produce protective stupefaction.

Further protective stupefaction tests were made at 50° F. with a very low prefumigation concentration and at 59° F. with relatively high prefumigation concentrations. The higher concentration which ranged from 0.28 mg. per liter at the start to 0.07 mg. at the end, is higher than any drift-gas dosages that have been observed in the field. The concentration of the final fumigations at both temperatures ranged from 2.35 mg. per liter at the start to 0.11 mg. at the end of 45 minutes. The

Table 2.—The influence of prefumigation with different concentrations immediately prior to fumigation and 2 hours earlier, on the mortality of mature females of the California red scale and scales in the second molt, at each of four temperatures.

Treatment	Interval Between Preliminary and Final Fumigation, Hours	Range of Prefumigation Concentration, Mg. per Liter	Mortality, Per Cent	
			Second Molt	Mature Female
Fumigation Temperature 50° F.				
Final fumigation only	—	—	85.5±2.2	99.9±0.1
Prefumigation and final fumigation	none	0.04–0.01	68.9±2.8	59.6±2.2
	none	.17– .04	59.0±1.9	80.4±2.7
	2	.04– .01	85.3±2.0	82.7±1.4
	2	.17– .04	85.3±1.5	85.2±1.4
Prefumigation only	—	.04– .01	7.3	7.3
	—	.17– .04	8.1	5.0
No fumigation	—	—	9.2	1.7
Fumigation Temperature 59° F.				
Final Fumigation only	—	—	71.7±2.6	98.3±0.3
Prefumigation and final fumigation	none	.04– .01	48.3±3.1	56.1±1.4
	none	.08– .02	44.8±2.8	55.8±2.3
	none	.17– .04	37.7±2.4	67.9±2.8
	2	.04– .01	54.2±3.1	85.6±1.2
	2	.08– .02	69.4±3.0	89.0±1.4
	2	.17– .04	69.9±2.5	91.2±1.3
Prefumigation only	—	.04– .01	8.0	8.2
	—	.08– .02	6.2	4.3
	—	.17– .04	6.2	3.2
No fumigation	—	—	4.2	0.8
Fumigation Temperature 68° F.				
Final fumigation only	—	—	78.5±1.4	98.4±0.4
Prefumigation and final fumigation	none	.04– .01	71.9±2.7	78.2±1.4
	none	.17– .04	56.2±2.3	75.2±2.1
	2	.04– .01	70.8±2.3	95.8±0.3
	2	.17– .04	80.5±2.3	95.7±0.7
Prefumigation only	—	.04– .01	7.8	9.8
	—	.17– .04	13.8	7.4
No fumigation	—	—	8.5	1.1
Fumigation Temperature 77°F.				
Final fumigation only	—	—	85.7±2.2	96.5±1.0
Prefumigation and final fumigation	none	0.04–0.01	84.5±2.6	91.7±1.0
	none	.17– .04	77.7±3.0	85.7±1.5
	2	.04– .01	79.5±2.6	98.5±0.6
	2	.17– .04	89.2±2.0	99.0±0.6
Prefumigation only	—	.04– .01	6.8	23.0
	—	.17– .04	11.2	13.3
No fumigation	—	—	6.8	3.0

prefumigations were also for 45 minutes. Mature females and scales in the second molt were included in each treatment and were both on the same fruit. The scales in the treatment at 50° F. were obtained in the field and those in the treatment at 59° F. were reared in the laboratory at fluctuating temperatures comparable to those in the field. Each mortality record is based on 1200 insects. The results are presented in table 3.

California red scale were tested in the laboratory under controlled conditions to determine the influence of different factors on the amount of protective stupefaction produced by prefumigation with a very low concentration of hydrocyanic acid prior to the regular fumigation concentration with the gas.

Mature female scales required less cyanide to stupefy them than scales in the second molt. With prefumigation, the

Table 3.—The influence of very low and relatively high prefumigation concentrations on the mortality of mature females of the California red scale and scales in the second molt.

Treatment	Interval Between Prefumigation and Final Fumigation Hours	Range of Prefumigation Concentration, Mg. per Liter	Mortality, Per Cent	
			Second Molt	Mature Female
Fumigation Temperature 50° F.				
Final fumigation only	—	—	82.3±1.9	99.7±0.2
Prefumigation and final fumigation	none	0.02 –0.008	81.0±1.9	88.3±1.9
	2	.025– .008	81.4±1.7	87.8±1.4
Prefumigation only	—	.02 – .008	7.2	5.3
No fumigation	—	—	6.3	2.8
Fumigation Temperature 59° F.				
Final fumigation only	—	—	97.2±0.6	99.5±0.2
Prefumigation and final fumigation	none	0.20 –0.05	55.4±1.6	75.5±2.4
	none	.28 – .07	49.5±2.2	87.9±1.3
	2	.20 – .05	88.6±1.4	83.5±2.0
	2	.28 – .07	87.8±1.1	78.4±1.5
Prefumigation only	—	.20 – .05	4.3	6.7
	—	.28 – .07	7.8	13.6
No fumigation	—	—	1.3	0.4

The scales in the second molt were not stupefied at 50° F. with the low prefumigation concentration but the mature female scales were, further indicating that scales in the former stage required higher concentrations to stupefy them than scales in the latter stage. At 59° F. the higher concentration immediately before the final fumigation produced more stupefaction in the second molt but the lower concentration had more effect on the mature female scales. There was stupefaction of both stages after a 2-hour interval between prefumigation and final fumigation. With the higher prefumigation dosage there was more stupefaction of the mature female scales after an interval of 2 hours than immediately after the prefumigation exposure.

SUMMARY.—Resistant individuals of the relative susceptibility of scales in the second molt and mature female scales was influenced by the prefumigation concentration. A higher prefumigation concentration was required to stupefy both stages as the temperature increased from 50° to 77° F. Some concentrations that produced protective stupefaction gave a slight mortality.

In general, the mature female scales remained stupefied longer than scales in the second molt. The period over which protective stupefaction continued was influenced by the prefumigation concentration and the temperature. With mature female scales the period decreased as the temperature increased from 50° to 77° F. and at 77° F. the kill of those stupefied 2 hours earlier was higher than that of those not subjected to protective stupefaction.

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The Potato Tuber Moth as a Host for Mass Production of *Macrocentrus ancylivorus*[1,2,3]

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The potato tuber moth, *Gnorimoschema operculella* (Zell.), has proved to be an ideal insectary host for the mass production of *Macrocentrus ancylivorus* Roh. The need of improved methods for mass production of *M. ancylivorus* in California is associated with the discovery of the oriental fruit moth, *Grapholitha molesta* (Busck), in that state in 1942. Also, it is now intended to test *M. ancylivorus* as a possible control for potato tuber moth in certain areas in California.

The larvae of the tuber moth are as suitable for parasitization by *M. ancylivorus* as any of its usual hosts. That such parasitization is not known to occur under field conditions suggests that the environment of the potato may not be frequented by *M. ancylivorus*. However, it may be due to the fact that the parasites of this insect have been insufficiently studied where it occurs in areas inhabited by the parasite.

The use of the potato tuber as a medium for propagating the host of *Macrocentrus* permits production the year around with a minimum of labor and of space.

The potato, if adequately infested, is completely utilized within 20 days. This allows a quick turnover of production material, conserves space and forestalls deterioration of potatoes due to rot and mites.

Since it is essential to have a continuous supply of tuber moths which is adequate for moth production as well as parasite production, separate moth and parasite units must be maintained. The moths escaping parasitization in the parasite units cannot be depended upon for infesting purposes.

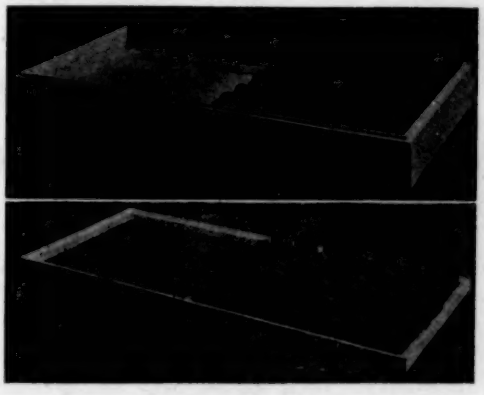

FIG. 1.—A partially loaded production unit and the tray removed from the unit.

DESCRIPTION OF EQUIPMENT.—The production units were designed to be movable and to encompass the production operations of infesting the potatoes, parasitizing the tuber moth larvae, and collecting the parasites.

A unit consists of an open box enclosing a tray (Fig. 1) for supporting a layer of potatoes. Under this tray is a layer of No. 61 chipboard which is creased and

[1] Paper No. 506, University of California Citrus Experiment Station, Riverside, Calif.

[2] Since so many requests have been received for information regarding methods of using the tuber moth for mass production of *Macrocentrus* it is felt that early publication of a progress report will be helpful. The technique is evolving rapidly and many details presented no doubt will have been modified by the time this report is in print. However, the technique here described has proved very successful and it is believed that modifications are likely to be limited to minor changes.—Harry S. Smith.

[3] Early publication of this paper has been secured by payment of the costs of printing.

[4] Principal Laboratory Technician.

[5] Associate Entomologist in the Experiment Station.

[6] Professor of Entomology and Entomologist in the Experiment Station.

FIG. 2.—Egg-deposition box.

perforated to form 12 sections each 17″ by 3.25″. This is covered with a thin layer of silt or fine sawdust. The box and tray are painted white inside and out. The box now in use is 42″ long and 18.5″ wide, outside, and 3.75″ deep inside. The ends and sides are 0.75″ white pine, and are rabbeted top and bottom so that when stacked the boxes nestle together (Fig. 4). The bottom of the box is of 0.25″ 3-ply wood set 0.5″ deep in the rabbeted sides. In each of the long sides of the box are two openings 18.75″×1.38″, covered on the inside with fine cheesecloth to provide light and ventilation. The lower edge of the opening is level with the upper edge of the potato tray.

The tray is 39.5″ long, 16.5″ wide, and 1.25″ high, and consists of a white pine frame of 0.75″×1″ material rabbeted 0.25″ deep and 0.5″ wide to receive a sheet of half-inch mesh hardware cloth 38.75″ long and 16″ wide. The frame rests on six wooden tabs 0.75″ square and 0.25″ thick fastened at each corner and the middle of each side.

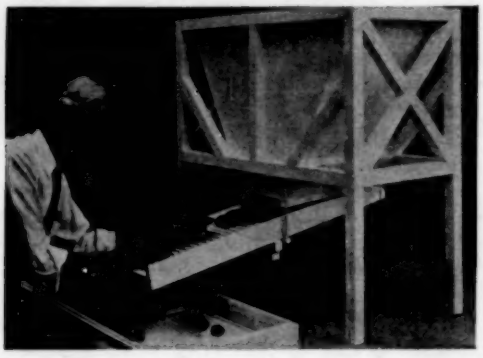

FIG. 3.—Hopper containing potatoes and the mitten method of puncturing them.

(Boxes and tray frames made of galvanized iron are also being tested.)

The platforms on which the units are stacked are 41″×24″×8″. Each platform is constructed to carry 20 units. The platforms are moved by means of a platform truck.

Moth egg deposition takes place within a box (Fig. 2) designed to take advantage of the positively phototropic and negatively geotropic habits of the adult moths. It is 38″ long, 15″ wide and 3″ high. The top and bottom consist of cloth (40″×17″) on which the moths deposit their eggs. Longcloth #60 has proved most suitable for the deposition of moth eggs. The cloths are held in place by wooden frames (1.5″ high) joined to the box by tongue and groove. A longitudinal plywood slide (3-ply: 0.25″×13.7″×39″) divides the box into two sections. These sections are used alternately as egg deposition chambers and moth emergence chambers. The lower section holds the cocooning cards from which the moths emerge; the upper section holds the egg-laying moths. The slide prevents the moths from ovipositing in the cocoons. When the slide is removed the slide opening is closed by means of a narrow "filler" stick. Above and below the slide opening are "peep" holes 0.63″ in diameter through which the movements of the moths are observed.

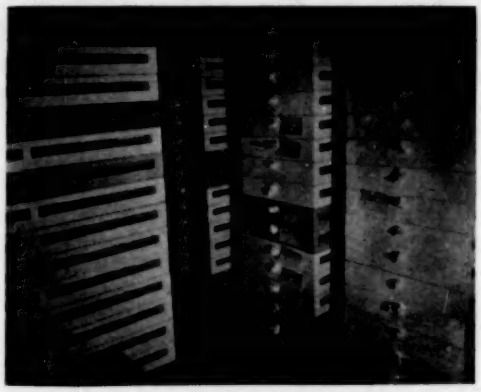

FIG. 4.—Units stacked during incubation period.

It has been found that *freshly* made punctures through the skin of the potato greatly increase the number of tuber moth larvae per potato. The potatoes may be readily punctured by rolling them under

leather mittens studded with brads placed 0.20″ apart (Fig. 3).

Potatoes may also be punctured by dropping them through a vertical chute 6′ high which contains 12 baffle boards set opposed to each other and at an angle of 45° to the horizontal. The portion of each board hit by the falling potatoes should be studded with brads 0.20″ apart. An automatic puncturing machine involving the use of belts studded with brads is also being tested.

Newly harvested potatoes, egg size and smaller, are most favorable for moth production. Such potatoes are used whole; when larger potatoes are used they are sliced in half lengthwise.

PROCEDURE IN PRODUCTION OF MOTHS AND PARASITES.—In the loading room the units are assembled as follows: Ten sections of chipboard are laid edge to edge crosswise of the bottom of the box and a layer of silt or sawdust about 0.06″ thick is evenly distributed upon the sheet thus formed to about 1″ from the edge of the sheet. This cocooning sheet which is 17″×39″ has an estimated maximum capacity of 10,000 cocoons. The tuber moth larvae show a decided preference for cocooning in media having the texture of silt or sawdust; consequently, very few cocoon in other parts of the unit as long as silt is available. A tray is then placed in the box so that at no point is it *less* than 0.20″ from the sides of the box. Punctured potatoes are then placed on the tray close together but with a minimum of contacts. Potatoes should not contact the sides of the box since cocoons may be constructed in crevices so formed. An egg cloth is then laid over the potatoes, egg side down. The newly hatched larvae move directly from the egg cloth into the potatoes. Potatoes not covered are only lightly infested. In units to be used for *Macrocentrus* production a strip of oiled paper about 20″×2″ coated with honey is laid over the box crosswise. When the loaded units are stacked one upon the other the honey strip is automatically suspended above the egg cloth.

The platforms of loaded units are moved to the incubation room, in which the temperature is about 80° F. and the relative humidity is about 40 per cent.

The temperature throughout the incubation room, inside as well as outside the units should be uniform for efficient propagation of moths and parasites. Temperatures within units may vary as much as 7° F. as a result of differences in the infestation in the potatoes. Rapid circulation of air between the stacks of units may be necessary to prevent this.

After one week in the incubation room the egg cloth is pulled out of each unit through a 1.25″ aperture in the end of the box and 100 females of *Macrocentrus* together with a number of males are injected through the aperture, which is then closed with a cloth-covered cotton wad. Light appears to be necessary for maximum oviposition. Thirteen days after the introduction of *Macrocentrus* the units are taken to the unloading room. The potatoes are dumped into garbage receptacles, the cocooning cards taken to the emergence room or the shipping room, and the boxes and trays thoroughly cleaned for reloading.

About 15 per cent of the units loaded daily are used for the production of moth breeding stock and about 10 per cent for the production of parasite breeding stock.

The cocooning cards from each of these parasite units are placed on hardware cloth trays and stacked in the emergence room. The parasites as they emerge from these trays gather on a lighted cloth screen where they are collected in tubes for injection into the units.

MOTH EGG PRODUCTION FOR BREEDING STOCK.—The cocooning cards from the moth units are cut in sections bearing about 500 cocoons each. Each of the egg deposition boxes (Fig. 4) receives one of these sections daily.

An egg deposition box is loaded and the moth eggs removed as follows: The box is placed on a table under a strong light.

The slide is removed and the opening closed with a "filler" stick. The box, after jarring it sharply to cause the newly emerged moths to move upward is shifted from its lower frame to a new cloth and frame. The box is then inverted so that the cloth with the day's production of eggs is at the bottom. It is again jarred sharply and shifted from the lower frame back to the frame bearing the cocooning cards. Then the slide is replaced. Two wooden platforms (11″×33″×1.25″) are used to facilitate the fastening of the cloths to the box. These platforms rest on the table within the frames and keep the

cloths from sagging while being placed in position.

While the box is being shifted from one frame to the other and back again a depleted cocooning card is replaced by a card from which moths are beginning to emerge. Cocooning cards remain in the egg deposition box 5 or 6 days before emergence of moths is completed.

Jarring of the egg-deposition box when the slide is removed causes above 90 per cent of the moths to collect in the upper half. Comparatively few moths escape during the shifting of the box. Dead moths accumulating on the lower cloth may be removed by means of a vacuum cleaner.

During egg deposition the egg box should be kept at a temperature of about 85° F. and 50 to 70 per cent relative humidity. An even distribution of eggs on the upper cloth is necessary in order to obtain uniform infestation after this cloth is placed on a tray of potatoes. Even egg distribution is obtained when the cloth is drawn taut and the top of the box kept unlighted. The boxes therefore may be kept in complete darkness.

Before the egg sheets are placed on the potatoes they are stacked on trays in a warm room until the eggs are about to hatch.

During the experimental work it was found that moths can be anesthetized with ether without reducing their production of eggs. Consequently it is probable that the procedure for obtaining moth eggs will be greatly modified.

PARASITE PRODUCTION FOR ORCHARD USE.—The time required for one turnover of material, that is, the period between the loading and unloading of a production unit is 20 days at a temperature of about 82° F. Moth egg sheets, adult parasites and clean units must be available at all times.

Each unit holds about 20 pounds of potatoes, which when well infested may yield over 4000 mature tuber moth larvae. Our maximum production from such a unit consists of about 800 adult moths and 1500 female and 1300 male *Macrocentrus*.

The sequence of events in the process of *Macrocentrus* production is as follows:

Days	*Events*
1	Moth egg deposition.
2, 3, 4	Moth egg incubation.
	Egg-sheet placed in production unit.
5, 6, 7, 8, 9	Eggs hatching and larvae entering potatoes.
	Egg-sheet removed from unit and parasites introduced.
10 to 22	Parasite oviposition and growth to second instar.
23	Unit unloaded and cleaned.
24 to 29	Period of moth emergence.
30 to 35	Period of parasite emergence.

Since the parasites are colonized while still in the host cocoons, it is desirable that all the tuber moths emerge from each cocooning card before it is placed in the field. This is brought about by the age uniformity of the infesting material and by withholding the parasites from the units as long as possible consistent with the obtaining of maximum parasitization.

THE LIBERATION OF PARASITES.—Our present plans for orchard colonization are as follows:

The cocooning sheets which contain *Macrocentrus* cocoons within the host cocoons will be assembled to form triangular cases. Each case is to be made up by tearing the sheets at the perforations, folding at the creases and banding with wire. Those with parasites about to emerge will be shipped in cardboard containers to the points of liberation, where they can then be suspended in the peach trees by the loose ends of the wire bands.—2-14-44.

Sources of Variations in the Effectiveness of Derris Dusts[1]

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Because of uncertainty as to the relative quantities and toxicities of the active principles other than rotenone present in derris root, it has been difficult to predict the relative insecticidal effectiveness of different samples of derris containing varying amounts of toxic constituents. Some success has been attained by making allowance, at different rates, for both rotenone and total extractives (Jones & Smith 1936); for rotenone, alkali-soluble resin, and alkali-insoluble resin (Martin 1940, 1942); and for the ratio of rotenone to total extractives (Hoyer & Leonard 1936).

Derris root, as sold on the market, is usually graded according to the content of rotenone and total extractives. In 1941 the writers conducted tests to determine whether effectiveness of derris-dust mixtures could be correlated with the rotenone content of the ground root, the content of total extractives, or a combination of the two as proposed by Jones & Smith, *i.e.*, rotenone (per cent + 0.5 × the percentage of other extractives). Several samples of derris root were each diluted in three ways—(1) to 0.1 per cent of rotenone, (2) to 0.4 per cent of total extractives, and (3) to 0.25 per cent Jones-Smith value, and the diluted dusts were applied in the laboratory against third instars of the Mexican bean beetle, *Epilachna varivestis* Muls. Since the different samples did not give the same effects by any of the systems of dilution, it was suspected that physical as well as chemical factors in the ground root influence effectiveness of dust mixtures. Then it was noted that further grinding of any powdered root improved its effectiveness. Also, one sample of very low rotenone content, requiring a large quantity of root to bring it to the same rotenone content as the rest of the mixed dusts in its series, was far more effective than could be explained on the basis of percentage of rotenone, percentage of total extractives, or particle size of the undiluted derris root. Experiments were therefore designed for studying the influence of the quantity and particle size of the ground root in the diluted dust on its effectiveness.

EXPERIMENTAL APPARATUS.—Particle-size determinations, based on observed densities, were made by the authors with an air-permeation apparatus described by Gooden and Smith (1940). This apparatus indicates a "surface-weighted average particle diameter," which is the diameter of a sphere having the same specific surface (area/volume) as the specific surface (total area/total volume) of the whole sample.

A two-walled cellulose acetate tower, approximately 9 inches in inner diameter and 40 inches high, was used to lay down uniform dust deposits. In operation a charge of derris powder, under 12 pounds' pressure, was blown up in a single puff through the bottom of the tower and allowed to settle for 2 minutes on the exposed under surfaces of four leaves of the common bean, *Phaseolus vulgaris*. After being dusted, the four leaves constituting one replicate were placed in randomized positions in cabinets regulated at 80° F. and 52 per cent relative humidity. Two third instar larvae of the Mexican bean beetle were introduced into a glass cylinder placed on each leaf and covered with wire screen. The percentage of feeding or leaf area consumed and the percentage of mortality were recorded at the end of 72 hours.

EFFECT OF PARTICLE SIZE.—In order that the influence of particle size on the effectiveness of derris-dust mixtures might be studied, a quantity of ground root (105-A) of large average particle size was converted into four samples of different average particle size, and each sample was then diluted with pyrophyllite of 3 microns' average particle size and mixed in a ball mill for 1 hour, to make a dust containing 0.1 per cent of rotenone. In table 1, 105-1 represents a part of 105-A that did not pass through a screen of 150 meshes to the inch; 105-A is the unaltered original sample as received through the dealer; 105-2 and 105-4 are samples of 105-A, ground in a Wedgewood mortar but not fractionated; and 105-3 is a sample of 105-A, ground and then air-floated.

[1] The writers acknowledge the kind assistance of Robert H. Nelson of the Bureau of Entomology and Plant Quarantine, and Earl L. Green, of Ohio State University. A further discussion of this study is being prepared.

[2] Agent, summers of 1941 and 1942.

Table 1.—Effect of particle size of derris dust on feeding and mortality of Mexican bean beetle larvae. Dust mixtures diluted to contain 0.1 per cent of rotenone from derris root 105-A (3.9 per cent rotenone; 17.8 per cent total extractives).

Dust Mixture	Derris, Average Particle Size	Charge, 18 mg.		Charge, 25 mg.		Average, Both Charges		Angle Equivalent to Mortality
		Feeding	Mortality	Feeding	Mortality	Feeding	Mortality	
	Microns	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Degrees*
105-1	19.0	56.1	18.7	50.6	20.8	53.3	19.7	26.37
105-A	10.8	44.4	36.1	31.9	35.4	38.1	35.7	36.72
105-2	8.2	22.1	43.8	18.1	39.6	20.1	41.7	40.22
105-3	7.0	28.3	39.6	14.3	45.8	21.3	42.7	40.79
105-4	6.9	21.2	58.3	13.3	64.6	17.2	61.4	51.63
Required difference at odds of 99 to 1		—	—	—	—	16.5	—	14.06

In the latter process the powder was blown up into the dust tower and the larger, heavier particles allowed to settle out for 20 seconds. A glass plate was then interposed and the particles settling in the next 3 minutes were collected as sample 105-3. Each dust treatment was replicated 12 times, 6 times with a charge of 18 mg. and 6 times with a charge of 25 mg. No replicate was duplicated on the same day.

The results, classified in column 5 in order of decreasing percentage of feeding (the preferred criterion of effectiveness, because it measures both the toxic and repellent action of the dust), indicate that the effect of particle size is directly related to the percentage of feeding and inversely related to the percentage of mortality. Grinding the dust from an average particle size of 10.8 microns to 6.9 microns almost halved the percentage of feeding, whether the charge was 18 mg. or 25 mg., the effect appearing more pronounced in the case of the higher charge. Data obtained by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine have shown that the smaller particle-size portion of a fractionated sample of derris powder yields a higher rotenone content than the coarser fraction. The low effectiveness of sample 105-1, therefore, may not be wholly attributed to the larger particle size. A comparison of the results obtained with samples 105-2, 105-3, and 105-4, however, suggests that the degree of fractionation accomplished by the air-float process had little influence on toxicity other than that resulting from decreasing the particle size.

As a second method of testing the influence of particle size on the effectiveness of derris-dust mixtures, chloroform extracts of ground root were used to impregnate two samples of pyrophyllite differing in average particle size. Two lots of 5.1 gm. of derris 105-A were soaked with 100 ml. of chloroform in a dark, cool chamber for 3 weeks, then filtered and washed with 100

Table 2.—The relation of particle size of dust to the effectiveness of pyrophyllite impregnated with derris extract.

	Charge 18 mg.	Charge 25 mg.	Average, Both Charges	Angle Equivalent to Mortality
Average particle size 5.5 microns				
Feeding	25.1%	21.5%	23.3%	
Mortality	46.7	54.1	50.4	45.23°
Average particle size 3.5 microns				
Feeding	14.1%	4.7%	9.4%	
Mortality	72.9	81.2	77.0	61.46°
Required Difference at Odds of 99 to 1			11.4	16.88°

ml. of chloroform. Two 144.9-gm. samples of pyrophyllite, one having an average particle size of 3.5 microns and the other 5.5 microns, were impregnated with the filtrates. The impregnated dusts were ball-milled for half an hour and 50 gm. more of the appropriate particle size were added to the parent samples. Particle-size determinations made after mixing the dusts in the ball mill an additional half-hour showed no change from the original observations.

Tests of dusts were replicated 6 times with a charge of 18 mg. and 6 times with a charge of 25 mg. The data presented in table 2 indicate that the impregnated sample of the smaller particle size was significantly more effective, as measured by the average percentage of feeding.

mately the same, there was a direct relationship between the proportion (number of particles per unit of mixed dust) of ground root and the effectiveness of the dust.

The effect of the number of toxicant particles per unit of mixed dust is also evident in tables 1 and 2. As the particle size decreased the difference in effectiveness between the 18-mg. and 25-mg. charges increased, indicating that, as the charge increased, the toxicity increased more rapidly in the fine particles than in the coarse. To augment these observations two series of pyrophyllite dusts were prepared, one in which all the particles were impregnated with derris extract, and the other in which only a small portion of the

Table 3.—Effectiveness of ground derris root when diluted with pyrophyllite so as to contain 0.1 per cent of rotenone.

Dust Mixture	Rotenone Content of Root	Total Extractives of Root	Average Particle Size	Root in Mixed Dust	Average	
					Feeding	Mortality
	Per Cent	*Per Cent*	*Microns*	*Grams*	*Per Cent*	*Per Cent*
105-A	3.9[1]	17.8	10.8	5.1	38.1	35.7
138	11.7	27.0	4.8	1.7	20.5	45.8
134-A	5.7	15.5	6.0	3.5	14.1	63.5
18-A	6.3	29.4	4.1	3.2	13.6	61.4
2-A	3.7	17.3	4.9	5.4	7.9	80.1
100-XA	.25	15.2	6.0	80.0	.3	95.8

[1] Analyses of the percentage of rotenone and of the total extractives of all the derris-root samples were made by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine.

EFFECT OF PROPORTION OF GROUND ROOT.—If particle size of the ground root is the most important factor influencing the effectiveness of mixed dusts of equal rotenone content, relative effectiveness of dusts made from different samples of derris root should be correlated with average particle size of the ground root. In table 3 are shown the results obtained with six different samples of derris root reduced with pyrophyllite of 3 microns average particle size to make completed dusts containing 0.1 per cent of rotenone. Each dust treatment was replicated 12 times—6 times with a charge of 18 mg. and 6 times with a charge of 25 mg.

Except for the least effective dust prepared from the ground root having the largest particle size, the results failed to show any relationship between particle size and effectiveness within the range of 4.1 to 6 microns. Where the particle sizes of the ground-root samples were approxi-

particles were impregnated. This procedure eliminated the effect of differences in particle size. In both series extractions were made from different samples of derris roots of sufficient quantity to produce 200 gm. of mixed dust containing 0.1 per cent of rotenone. The samples were soaked in 100 ml. of chloroform for 6 days, excepting sample 2-A, which was soaked only 5 days, and sample 100-XA, which was soaked in 200 ml. of chloroform for 6 days. The solutions were then filtered and the residue washed with 25 ml. of chloroform. The first series was completed by impregnating quantities of pyrophyllite equal in number of grams to the quantities of ground root extracted, then mixing it in a ball mill for half an hour with sufficient nonimpregnated pyrophyllite to make 200 gm. of completed dust. The second series was completed by adding 100 ml. of chloroform to each filtrate and impregnating approximately 200 gm. of pyrophyllite.

Table 4.—Influence of the number of toxicant particles per unit of mixed dust on the effectiveness of the impregnated dusts when the rotenone content was held constant. Total quantity of each mixed dust, approximately 200 gm. In series 1 only a small portion was impregnated; in series 2 the total quantity was impregnated.

Dust Mixture	Series 1			Series 2		
	Pyrophyllite Impregnated	Average, Both Charges		Pyrophyllite Impregnated	Average, Both Charges	
		Feeding	Mortality		Feeding	Mortality
	Grams	*Per Cent*	*Per Cent*	*Grams*	*Per Cent*	*Per Cent*
2-A	5.4	57.0	27.1	194.6	1.2	93.7
138	1.7	40.8	36.8	198.3	7.7	80.2
105-A	5.1	40.7	31.8	200.0	21.9	56.2
134	3.5	31.9	30.2	196.5	3.2	88.5
18-A	3.2	31.4	41.7	196.8	6.8	83.3
100-XA	80.0	.5	98.9	200.0	.4	100.0

Each dust was ground in a ball mill for half an hour. Paired dusts in both series were therefore assumed to have the same rotenone content, as well as the same particle size.

The results of testing the impregnated mixtures are shown in table 4. Each dust was replicated twelve times in both series, six times with a charge of 18 mg. and six times with a charge of 25 mg. It appears that, when the rotenone content is the same, the greater the number of toxicant particles per unit in an impregnated dust the greater the effectiveness.

EFFECT OF TOXIC EXTRACTIVES.—If particle size and proportion of ground root are the main physical factors of the dusts that influence toxicity, and if these factors are held constant, the relative effectiveness of different derris mixtures should vary as the chemical toxicity of the roots. Treatments, replicated eight times with a charge of 18 mg., were made with four derris mixtures containing the same quantities of ground root and pyrophyllite. The particle size of the ground root used in all mixtures was approximately the same, whereas a marked difference existed in the rotenone content, the most toxic of the constituents. In the percentage of feeding, as is shown in table 5, there is a significant difference between mixtures containing ground root of the same particle size, the effectiveness varying with the rotenone content. The same conclusions could also be reached by considering the samples as two pairs.

DISCUSSION.—The foregoing results indicate that the toxicity of derris dusts depends on the chemical and physical properties of the ground root. Both grinding the root and increasing the ratio of toxicant to diluent increased the effectiveness of the dust mixtures. An increase in effectiveness would be expected in the latter case if the completed dust were higher in rotenone content as the result of increasing the quantity of ground root. The results indicate, however, that increasing the number of toxicant particles per unit

Table 5.—Results of testing four derris mixtures containing the same quantities of ground root (2.5 gm.) and pyrophyllite (197.5 gm.).

Dust Mixture	Derris Average Particle Size	Rotenone	Total Extractives	Charge, 18 mg.		
				Feeding	Mortality	Angle Equivalent to Mortality
	Microns	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Degrees*
100-XA	6.0	.25	15.2	64.3	21.9	27.90
134-A	6.0	5.7	15.5	35.2	35.4	36.51
2-A	4.9	3.7	17.3	32.9	47.5	43.57
138	4.8	11.7	27.0	10.9	77.2	61.48
Required difference at odds of 99 to 1		—	—	17.5	—	19.60

of mixed dust increases the effectiveness of the derris-dust mixtures independently of the total concentration of extractives in the dust. Apparently a greater area of toxicant comes into contact with the insects' absorbing surfaces and favors more rapid and complete extraction of the toxic principles. Grinding the particles also increases the contact surface area of the toxicant, *e.g.*, 10 particles 20 microns in diameter and 1000 particles 2 microns in diameter would have the same total surface area, but the contact surface area would be much greater in the latter instance. In connection with this example it may also be stated that if these particles are assumed to be spheres, while both the large and small particles have the same surface area, the larger particles have 10 times the volume of the smaller particles.

From these laboratory observations it appears that derris could be used very efficiently by extracting and impregnating dust carriers of small particle size. C. L. Smith (1936), however, found that grinding pyrethrum powder increased the rate of deterioration upon exposure to light and air. Although derris dusts do not lose their toxicity so rapidly as pyrethrum dusts, it is probable that under field conditions, as the surface area of the toxicant is increased, the rate of deterioration will also be increased from weathering. The degree of increase in rate of deterioration will determine the practicality of decreasing the particle size of ground derris root and the use of impregnated dusts containing derris extracts.

SUMMARY.—Derris-dust mixtures prepared from different samples of roots and containing equivalent rotenone concentrations are subject to marked variations in effectiveness when applied in the laboratory against larvae of the Mexican bean beetle. Tests were conducted to determine the source of these variations. It was found that effectiveness of derris-dust mixtures depends on both the chemical and the physical properties of the ground root. Effectiveness varies inversely as the particle size, directly as the number of toxicant particles per unit of mixed dust, and directly as the rotenone content when any two of these variables are held constant. Impregnated or coated dusts of similar particle size vary in effectiveness directly as the number of toxicant (coated) particles per unit of mixed dust.

The physical properties were interpreted as influencing the rate and quantity of toxicant absorption by determining the surface area of the toxicant coming into contact with the absorbing surfaces of the insect.

It appears that preparation of derris-dust mixtures should include some compensation for differences in the number of toxicant particles per unit of mixed dust as influenced by particle size and proportion of ground root, instead of being prepared entirely according to the active chemical constituents.—11-17-43.

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Laboratory Tests of Synthetic Organic Compounds as Insecticides

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Several years ago a paper was published (Swingle *et al.* 1941), describing the equipment and certain methods used at the insecticide testing laboratory of the Bureau of Entomology and Plant Quarantine at Sanford, Fla. Since that time three other manuscripts, not yet published, have been prepared, presenting the results of insecticide tests on 984 compounds. The present paper is a continuation of the report on the preliminary testing of miscellaneous organic compounds and presents the data obtained on 82 additional compounds.

The materials tested were supplied by the Division of Insecticide Investigations and were prepared under the direction of R. C. Roark and H. L. Haller of that Division. All the samples to be tested were undiluted compounds, and many of them were relatively coarse, compared with the particle size of commercial insecticides, because no special processing was employed to reduce the particle size. This fact should be considered in judging the results presented, because it has been shown that particle size influences the effectiveness of insecticides (McGovran *et al.* 1940).

The method used in the preliminary testing of these compounds has been described in a previous paper (Swingle *et al.* 1941). Briefly, each compound was applied as a dust to excised leaf sections, which were then fed to insects in closed petri dishes. Both sides of the leaves were dusted, but the deposit reported in the table is for one surface only. From two to three dishes, containing a total of 25 to 30 insects, were used in each test.

The preliminary tests were made on chewing insects, mostly lepidopterous larvae. These were from laboratory reared stocks and were used in the fourth or fifth instar, or when nearly full-grown. Adults of the blister beetle *Epicauta lemniscata* F. were the only insects used in this stage and were all field-collected. Eleven species of insects were used in the tests reported in table 1. The common names used in this paper are those approved by the American Association of Economic Entomologists.

Of the 82 compounds reported in this paper, only 11 were sufficiently toxic to warrant discussion, and none of these were outstanding as insecticides. The results obtained in these preliminary tests of foliage dusted with the 11 most toxic samples are given in table 1. The compounds which were found to be most toxic to the greater number of insects were 2-chloro-6-nitrotoluene, 4-chloro-2-nitrotoluene, and p-nitrophenyl ester of acetic acid. An iodine-substituted nitrotoluene was also among the 11 most toxic compounds, but it was definitely inferior to the two chlorine compounds.

In addition to the tests reported in table 1, a number of others have been made on these compounds to obtain a more comprehensive knowledge of their insecticidal action. As the compounds were found to be toxic to insects, they were tested for volatility to determine the stability of dust or spray deposits. This was determined by weighing a dusted glass slide before and after a 5-day period of exposure to average room conditions. The samples found to be 100 per cent volatile in 5 days were d-bromo-camphor, 2-chloro-6-nitrotoluene, 4-chloro-2-nitrotoluene, and 8-quinolinol.

These volatile samples were next tested as fumigants by confining insects in a saturated vapor in petri dishes or half-pint jars. The vapors of 2-chloro-6-nitrotoluene and of 4-chloro-2-nitrotoluene were found to be very toxic to adults of the cowpea weevil and to nearly full-grown larvae of the Hawaiian beet webworm, imported cabbage worm, melon worm, southern armyworm, and southern beet webworm. When mixed with sand at the rate of 1 to 1000 parts by weight, these two compounds caused 100 per cent mortality of adult termites in laboratory tests similar to those made by Hockenyos (1939). At 1:5000, 2-chloro-6-nitrotoluene caused 100 per cent mortality, but 4-chloro-2-nitrotoluene killed only 24 per cent of the termites. Neither of the two

Table 1.—The results of preliminary insecticidal tests of 11 synthetic organic compounds (as dusts on leaves).

COMPOUND	INSECT AND STAGE[1]	DEPOSIT m/sc[2]	PER CENT MORTALITY AFTER 2 DAYS	FEEDING[3]
d-Bromocamphor	Hawaiian beet webworm (5)	200	16	N
$C_{10}H_{15}BrO$	Imported cabbage worm (5)	200	52	M
	Melon worm (4)	200	56	N
	Southern armyworm (4)	155	0	H
	Southern beet webworm (5)	385	97	S
Chloral acetamide	Cross-striped cabbage worm (5)	370	7	M
$C_4H_6Cl_3NO_2$	Hawaiian beet webworm (5)	225	52	M
	Melon worm (4)	260	65	S
	Southern armyworm (4)	225	0	M
2-Chloro-6-nitrotoluene	Hawaiian beet webworm (5)	200	96	N
$C_7H_6Cl\ NO_2$	Melon worm (4)	200	100	N
	Southern armyworm (4)	340	93	N
	Southern beet webworm (5)	405	100	N
4-Chloro-2-nitrotoluene	Hawaiian beet webworm (5)	125	96	N
$C_7H_6Cl\ NO_2$	Melon worm (4)	125	100	N
	Southern armyworm (4)	385	87	S
	Southern beet webworm (5)	280	100	S
gamma, gamma-Dipyridyl	Blister beetle (A)	260	64	S
$C_{10}H_8N_2$	Hawaiian beet webworm (5)	355	92	S
	Melon worm (4)	250	71	S
	Southern armyworm (4)	250	0	H
	Southern beet webworm (5)	325	97	S
2-Iodo-3-nitrotoluene	Blister beetle (A)	500	50	S
$C_7H_6I\ NO_2$	Hawaiian beet webworm (5)	465	73	N
	Imported cabbage worm (5)	485	36	M
	Melon worm (4)	465	36	N
	Southern armyworm (4)	295	0	H
	Southern beet webworm (5)	355	30	S
	Yellow woolly bear (4)	620	48	S
p-Nitrophenyl ester of acetic acid	Blister beetle (A)	185	76	N
$C_8H_7NO_4$	Greenhouse leaf tier (4)	230	100	N
	Hawiian beet webworm (4)	230	96	S
	Melon worm (4)	310	100	S
	Southern armyworm (3)	230	93	S
	Southern beet webworm (4)	310	100	N
	Yellow woolly bear (4)	395	48	M
p-Nitropropionanilide	Hawaiian beet webworm (5)	265	20	S
$C_9H_{10}N_2O_3$	Imported cabbage worm (5)	265	16	H
	Melon worm (4)	265	8	S
	Southern armyworm (4)	230	0	H
	Southern beet webworm (5)	195	23	M
Phenanthrene	Colorado potato beetle (4)	360	100	S
$C_{14}H_{10}$	Diamondback moth (4)	360	27	S
	Greenhouse leaf tier (5)	360	0	H
	Hawaiian beet webworm (5)	230	4	H
	Melon worm (4)	230	0	H
	Southern armyworm (3)	360	83	S
	Southern beet webworm (4)	230	11	M
	Yellow woolly bear (6)	360	0	H
2-Quinolinol	Blister beetle (A)	165	0	S
C_9H_7NO	Hawaiian beet webworm (5)	310	52	M
	Imported cabbage worm (5)	230	0	H
	Melon worm (4)	230	20	S
	Southern armyworm (4)	265	0	H
	Southern beet webworm (5)	310	77	S

Table 1.—*Continued*

Compound	Insect and Stage[1]	Deposit m/sc[2]	Mortality After 2 Days	Feeding[3]
8-Quinolinol C_9H_7NO	Hawaiian beet webworm (5)	295	57%	S
	Imported cabbage worm (5)	310	42	M
	Melon worm (4)	310	18	N
	Southern armyworm (4)	380	53	S
	Southern beet webworm (5)	380	83	S
Barium fluosilicate	Blister beetle (A)	193	54%	M
Derris (4.8% rotenone)	Colorado potato beetle (4)	233	100%	S
	Cross-striped cabbage worm (4)	220	75	S
	Diamondback moth (4)	250	100	N
	Hawaiian beet webworm (5)	137	73	S
	Imported cabbage worm (5)	60	90	S
	Melon worm (4)	150	60	S
Lead arsenate	Southern armyworm (4)	118	69%	S
	Yellow woolly bear (4)	186	47	M
Pyrethrum (1.2% pyrethrins)	Greenhouse leaf tier (4)	295	83%	S

[1] Figure refers to number of larval instar; A means adult.
[2] Micrograms per square centimeter of leaf surface.
[3] N = none; S = slight; M = moderate; H = heavy.

compounds was effective against nearly full-grown nymphs of the American cockroach, which were confined for 2 days on a surface heavily dusted with the compounds. When mixed with Crowder peas and wheat at the rate of 1 to 1000 parts by weight, both compounds killed 100 per cent of adult cowpea and rice weevils confined in petri dishes with the treated seed. Applied as contact sprays (8 lbs. per 100 gals.), neither compound was effective against second instars of the squash bug, full-grown nymphs of the pea aphid, and fourth instars of the southern armyworm and Hawaiian beet webworm.

d-Bromocamphor, a volatile compound, was not toxic as a fumigant to adults of the cowpea and rice weevils. Mixed with sand at 1:1000, it killed 100 per cent of adult termites but was ineffective at 1:5000. Mixed with Crowder peas at 1:1000, the compound killed adults of the cowpea weevil but was not effective against rice weevils in wheat. It was not effective as a dust against the American cockroach.

Chloral acetamide, one of the less toxic compounds, was tested against adults of the cowpea and rice weevils by mixing it with seed at 1 to 1000 parts by weight. The compound was not toxic to these weevils.

Gamma, gamma-dipyridyl was not volatile and was tested further as a contact and stomach insecticide. As an undiluted contact dust it killed 100 per cent of second-instar squash bugs. As a stomach insecticide spray applied to foliage (8 lbs. per 100 gals.) it killed 100 per cent of adult blister beetles and 96 per cent of the fourth-instar melon worms. It was toxic, but not very effective, against larvae of the southern beet webworm. At 4 pounds per 100 gallons the compound was not very effective against adult blister beetles.

2-Iodo-3-nitrotoluene was found to be slightly volatile (39 per cent) in 5 days. As a fumigant it was not toxic to larvae of the melon worm or imported cabbage worm. It killed 100 per cent of adult termites when mixed in sand at 1:1000 but was not effective at 1:5000. Mixed with grain at 1:1000, it killed 100 per cent of adults of the cowpea and rice weevils. It was not effective as a contact dust against the American cockroach or as a stomach insecticide spray against larvae of the Hawaiian beet webworm, melon worm, southern beet webworm, and adults of the blister beetle.

p-Nitrophenyl ester of acetic acid was relatively nonvolatile and was ineffective as a dust against the roach and as a grain treatment for the rice weevil. As a contact dust it killed 97 per cent of second-instar squash bugs and 60 per cent of adult harlequin bugs. As a stomach insecticide spray (8:100), the compound was effective against the melon worm but was not toxic

to larvae of the southern army worm or southern beet webworm or to adult blister beetles.

p-Nitropropionanilide was not toxic to termites at 1:1000 or to adults of the cowpea or rice weevils in treated grain. As a stomach insecticide spray (8:100) it killed 86 per cent of melon worm larvae.

Phenanthrene killed 100 per cent of termites at 1:1000 in sand but was relatively ineffective at 1:5000. It was also ineffective as a grain treatment against the rice weevil. An 8:100 spray killed 75 per cent of the cabbage aphid, but it was not effective as a stomach insecticide with southern armyworm larvae.

2-Quinolinol was not toxic to termites or to weevils in treated grain. An 8:100 spray, however, killed 100 per cent of melon worm larvae as a stomach insecticide.

8-Quinolinol, a volatile compound, was not effective as a fumigant against weevils and leaf-feeding larvae. As a soil treatment it killed 60 per cent of termites at 1:1000 but was not effective at 1:5000. As a seed treatment at 1:1000 the compound killed 100 per cent of the cowpea weevils but only 53 per cent of the rice weevils. As a contact dust it was relatively ineffective against cockroaches.

In addition to the 11 compounds previously discussed, 72 other compounds were tested during the same period, but they were found to have little or no toxicity as insecticides to the insects used, when treated by the methods used. These compounds were tested on from 5 to 9 of the following species of insects: Fourth instars of the bean leaf roller, cabbage webworm, Colorado potato beetle, cross-striped cabbage worm, diamondback moth, greenhouse leaf tier, Hawaiian beet webworm, imported cabbage worm, melon worm, southern armyworm, southern beet webworm and yellow woolly bear; and also against adults of the blister beetle *Epicauta lemniscata*, cowpea weevil, rice weevil, termites, *Reticulitermes* sp., and large nymphs of the American cockroach. The 72 compounds tested and found relatively nontoxic are the following:

6′-Acetoxy-coumarano-2′,3′:3,2-(6-acetoxy-2,3,diphenyl)-coumarane
2-Amino-5-chlorobenzoic acid
3-Aminodibenzothiophene-5-dioxide
Anisic acid
9-Anthrylphenyl ketone
Barbituric acid
5-Benzalamino-o-cresol
p-Benzal aminophenol
N,N′-Benzal bisacetamide
N,N′-Benzal bisbenzamide

N,N′-Benzal bisformamide
N,N′-Benzal bispropionamide
N,N′-Benzal bispyromucamide
N,N-Benzal bisurea
N-Benzal-1-naphthylamine
N-Benzal-2-thiohydantoin
N-Benzal xenylamine
N-Benzal-2-5-xylidene
Benzene sulfonyl chloride-ammonium thiocyanate reaction product
Benzohydrol

2-Benzoylbenzoic acid
3-Benzoyl dibenzofuran
beta-Benzoyl propionic acid
2,5-Bis(phenylthio)quinone
2,6-Bis(phenylthio)quinone
4′-Bromo-2-benzoylbenzoic acid
9-Bromophenanthrene
5-Carbethoxy-2-keto-6-methyl-4-phenyl-1,2,3,4-tetrahydropyrimidine
Chalcone
Chloral formamide

4′-Chloro-2-benzoylbenzoic acid
6-Chlorocoumarin
4-Chloro-4′-methylbenzophenone
4-Chloro-beta-phenylanthraquinone
4′′-Chloro-4′-phenyl-2-benzoylbenzoic acid
Copper phthalocyanine
2,4-Diacetaminodiphenylamine
Dibenzothiophene-5-dioxide
Dichloral glucose
2,4′-Dichlorobenzophenone

4,4′-Dichlorobenzophenone
1-2-Dihydro-4,6-dihydroxy-2-phenyl-S-triazine
1-2-Dihydro-4,6-dimercapto-2-phenyl-S-triazine
2,4′-Dihydroxybenzophenone
4,4′-Dihydroxybenzophenone
p-Dimethylaminobenzaldehyde
2,4-Dimethyl-6-nitroacetanilide
5,6-Diphenyl-3-hydroxy-1,2,4-triazine
beta,beta-Diphenyl propionic acid
beta-Glucochloralose

6′-Hydroxy-coumarano-2′,3′:3-2-(6-hydroxy-2,3-diphenyl)-coumarane
p-Methyl benzophenone
Methylene amino acetonitrile
Morpholine thiuramdisulfide
beta-Naphthalene sulfonyl chloride-ammonium thiocyanate reaction product
3-Nitroacetophenone
6-Nitro-1,3-benzodioxane
3-Nitrodibenzothiophene-5-dioxide
6-Nitroquinoline
8-Nitroquinoline

Phenanthraquinone
p-Phenylacetophenone
Phenyl-3-buten-2-one
Phthalic anhydride monoxime (white form)
Phthalic anhydride monoxime (yellow form)
6′-Propionoxy-coumarano-2′,3′:3,2-(6-propionoxy-2,3-diphenyl)-coumarane
Sulfur thiocyanate
Trichloroacetamide

Tri-p-cresyl phosphate
Triphenyl phosphate
Triphenyl thiophosphate

SUMMARY.—The results of laboratory insecticide tests made to determine the possible effectiveness of 82 synthetic organic compounds are briefly discussed. The compounds were tested against from 5 to 9 of 16 different species of insects, and 11 of the compounds were found to be moderately toxic to the insects used. The most effective compound was 2-chloro-6-nitrotoluene, which is a volatile material and was effective as a fumigant. None of the compounds appeared useful as practical insecticides.—10-29-43.

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Value and Use of Volatile Nitriles for Household Fumigation[1]

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Research of recent years has brought forth several new fumigants and has shown that several groups of compounds possess promising insecticidal characteristics. Among these is a group with the general formula, RCN, known as the nitriles. Certain of these compounds have been found to be very toxic to insects but not dangerous to warm-blooded animals. Among those that have been considered as fumigants are monochloroacetonitrile ($CLCH_2CN$), trichloroacetonitrile (CL_3CCN), and acrylonitrile (CH_2CHCN). These are colorless liquids at room temperature, boiling at 127°, 85°, and 78° C. respectively. As they are quite volatile, artificial heat is not necessary to evaporate the liquids for fumigation work. Acrylonitrile is flammable within the limits of 3 per cent and 17 per cent by volume in air, whereas the other two compounds are not flammable in any proportions. The chloroacetonitriles are lacrymators.

This paper reports a study of the use of trichloroacetonitrile and a 50–50 mixture of trichloroacetonitrile and acrylonitrile under several controlled conditions of moisture and temperature in a fumigation chamber and under existing conditions in practical house fumigations.

PREVIOUS WORK.—V. Migrdichian[2] (unpublished data) found that acrylonitrile was very toxic to insects. William Moore[2] (unpublished data) determined that various halogen-substituted acetonitriles, including monochloroacetonitrile and trichloroacetonitrile, were effective fumigants. C. S. Barnhard[3] (unpublished data) developed the information that monochloroacetonitrile aired out of dwellings much too slowly for satisfactory household fumigation, although it had many desirable features. Peters (1940) reported very favorably on trichloroacetonitrile as a household fumigant. He stated that it aired out of houses so rapidly that the occupants could return the night following a daytime 8-hour fumigation.

Dudley & Neal (1942) found that the symptoms produced by acrylonitrile on most warm-blooded animals are typical of cyanide poisoning, and they concluded that the order of toxicity of hydrocyanic acid and acrylonitrile is similar when compared on the basis of their cyanide content. Dudley *et al.* (1942) obtained evidence that this compound has no cumulative action when administered to warm-blooded animals in sublethal doses at daily intervals over a period of several months. It has no warning property. There is no information on the toxicity of acrylonitrile to man. Moore found that the lethal dosages for monochloroacetonitrile and trichloroacetonitrile to white mice were one-tenth those for HCN.

[1] A project of The Ohio State University Research Foundation in cooperation with the American Cyanamid and Chemical Corporation, New York, N. Y.; supervised by Professor F. L. Campbell.

[2] American Cyanamid Company, Research Laboratories, Stamford, Conn.

[3] Investigator of the Ohio State University Research Foundation, 1941.

Peters (1940) states that trichloroacetonitrile is about as toxic to warm-blooded animals as ethylene oxide and methallyl chloride. It irritates the eyes, nose and throat at concentrations that are not immediately dangerous, thus practically excluding the possibility of poisoning.

Richardson & Casanges (1942) found that acrylonitrile and monochloroacetonitrile were not as toxic to the confused flour beetle as HCN but were more toxic than any of the other common fumigants. They observed that acrylonitrile and monochloroacetonitrile had a delayed action on the confused flour beetle; *e.g.*, at the end of a fumigation with a killing dose, the insects appeared normal but died after 6 hours.

METHODS AND MATERIALS.—The atmospheric chamber used for testing the performance of the fumigants under various conditions was 11.5 by 9 by 6.5 feet with a 740 cubic foot volume. Under the slatted false floor, which was 4 inches above the real floor, were the heating pipes. The temperature in the chamber was maintained at any desired level above that of the surrounding room. The chamber was furnished as a bedroom with a bed, cotton mattress, feather pillow, sideboard, mirror, trunk full of clothes and blankets, composition box of clothes, etc. It was equipped with an exhaust fan, which at half speed removed or recirculated the vapors at the rate of 2 chamber volumes per minute and at full speed at 4 volumes per minute. Temperatures of 75° to 85° F. were maintained during the warm tests, while 55° to 60° F. was the range for the cool tests. So-called dry tests were made during the summer in dry weather and during the winter when the relative humidity was usually less than 20 per cent. The so-called damp tests were made after the contents of the chamber had been dampened and the relative humidity brought close to 100 per cent by sprinkling water about the chamber while the air was being recirculated.

The effectiveness of each fumigation was measured by the kill of the test insects in glazed, unperforated pill boxes distributed throughout the chamber. For each test five boxes of last instar or adult bedbugs, five boxes of adult confused flour beetles, and five boxes of black carpet beetle larvae were used. The numbers of insects per box were 10, 10, and 4 or 5 respectively. The boxes were placed in the same positions for each fumigation. Counts of dead insects were made 48 hours later; any moribund insects were kept under observation until they recovered completely or died. The same species of insects in the same type of boxes were used in the house fumigations.

The trichloroacetonitrile was used alone in half the chamber tests and in some of the house fumigations. The acrylonitrile was used always in a 50–50 mixture by volume with the trichloroacetonitrile, making a combination nonflammable up to 14 pounds per 1000 cubic feet. For application the desired quantities of the liquids were easily measured out in graduated cylinders and poured into large-mouth gallon jars containing absorbent pellets about the size of small peas (*Johns Manville Celite Catalyst Carrier, type VI*). As much as 1.3 cc of liquid was absorbed per gram of pellets. To release the fumigant by evaporation, the charged pellets were poured from the jar upon 16 mesh screening. As the vapor of trichloroacetonitrile is nearly 5 times heavier than air, the screens were elevated from the floor. In the chamber the screen was suspended about a foot from the ceiling. In the house fumigations the 2 by 3 foot screens were placed on top of wooden tripods, made from three 6-foot lengths of 0.75 inch molding tied together 2 feet from the top by heavy cord. After a fumigation the pellets were poured into a long box and could be used over and over again.

It is desirable to wear a gas mask while charging the pellets and distributing them on the screens; a gas mask must be worn when a house under fumigation is to be entered.

The rate of aeration of the vapors after a fumigation was measured by eye tests and charcoal sorption tests. The first was made by finding the length of time a person could lie face down on a feather pillow with the eyes open before experiencing eye irritation. When irritation did not result after a period of 7 or 8 minutes, complete aeration was indicated. The other test is semi-quantitative and when made in the following manner was closely correlated with the eye test. A half gram of 40 to 50 mesh activated charcoal resting on a 7 cm filter paper is placed on a pillow or mattress under a petri dish lid for 20

Table 1.—Summary of the results of chamber fumigations with nitriles at 1 pound per 100 cubic feet.

Conditions			Per Cent of Test Insects Killed			Hours for Aeration		
Exposure (hours)	Temperature	Moisture	Bedbugs	Carpet Beetle Larvae	Flour Beetles	Sideboard	Mattress	Pillow
			Trichloroacetonitrile					
6	high	dry	100	90	100	4	4	7
6	high	damp	100	100	100	6	6	12
6	low	dry	94	70	82	2	2	4
6	low	damp	88	65	78	—	—	—
12	high	dry	100	100	100	2	4	5
12	high	damp	100	100	100	1	6	13
12	low	dry	100	84	100	3	5	7
12	low	damp	100	100	100	6	6	9
			Trichloroacetonitrile-Acrylonitrile (50–50)					
6	high	dry	96	84	94	2	2	5
6	high	damp	100	95	100	4	5	10
6	low	dry	94	50	98	—	—	—
6	low	damp	100	20	78	—	—	—
12	high	dry	100	100	100	2	2	6
12	high	damp	100	100	100	5	5	8
12	low	dry	100	75	100	6	6	8
12	low	damp	100	90		6	7	13

minutes. After transferring the exposed charcoal to a large test tube and adding 2 cc of a sodium hydroxide solution (10 g NaOH pellets in 90 cc H_2O), the tube is held in a flame until the contents boil. As soon as boiling ceases, a strip of damp *Gramercy pH Range Finder Paper* is held in the mouth of the tube. If trichloroacetonitrile is present, ammonia is given off and turns the paper green or blue, the color depending on the quantity released. When testing for acrylonitrile the charcoal must be treated with concentrated sulfuric acid before applying a stronger sodium hydroxide solution (50 g NaOH pellets in 50 cc H_2O).

Chamber Tests.—Half the tests were made with trichloroacetonitrile alone and the other half with the trichloroacetonitrile-acrylonitrile mixture. With each material half were 6-hour fumigations and half 12-hour fumigations. Under each of these 4 combinations of materials and exposures the following conditions were maintained: warm-dry, warm-damp, cool-dry, and cool-damp, making a total of 16 tests. A dosage of 1 pound per 1000 cubic feet was used in all the tests. Since these tests were designed to measure differences in performance, if any, under the varying atmospheric conditions, a dosage was selected which might give incomplete kills in some cases.

A summary of the results of the tests with trichloroacetonitrile and with the trichloroacetonitrile-acrylonitrile mixture is given in table 1. These data show that (1) these fumigants were more effective at the higher temperatures, (2) temperature did not influence the period of aeration of the fumigants, (3) moisture did not influence the effectiveness of the fumigants, (4) moist conditions prolonged the aeration period by several hours, (5) the length of the exposure did not influence the period of aeration and (6) the 12-hour exposure was consistently more effective than the 6-hour.

Increasing the moisture content of the furnishings within a day or two after a fumigation caused eye irritation after the eye test had become negative under dry conditions.

House Fumigations.—The trichloroacetonitrile and the trichloroacetonitrile-acrylonitrile mixture were used in four house fumigations, two single apartment fumigations and in a 4-room section of a university building. The buildings were prepared for fumigation just as they would have been for any other fumigant. Scotch masking type was used for sealing windows, etc.

In the first fumigation in a leaky house trichloroacetonitrile at 1 pound per 1000 cubic feet with a 6-hour exposure did not

kill all the insects. Aeration was so rapid that the occupants returned without discomfort 3.5 hours after ventilation began. The second and third fumigations were made in a well-constructed, modern home using the 6-hour exposure. In the second, trichloroacetonitrile at 2 pounds per 1000 cubic feet killed all the test insects. Aeration was completed in a few hours, and the supervisor and the writer slept in the house the same night without discomfort or ill effects. No damage resulted to any of the furnishings. The 50–50 mixture was used in the third fumigation at 1.5 pounds per 1000 cubic feet. All insects were killed, aeration was rapid enough for reoccupancy the same night and no damage resulted. The fourth fumigation was in a large, well-built house. The mixture, used at 1 pound per 1000 cubic feet with a 12.5-hour exposure, proved to be inadequate to kill all the test insects in well protected places. Bedbugs were killed in all locations with the exception of one closed bureau drawer. Clothes moth larvae were among those insects surviving at this dosage. Aeration was rapid, and no damage resulted. The fifth and sixth fumigations were made in a 3-room apartment in an old apartment building to determine the possibilities of these fumigants for the treatment of rooms in partially occupied buildings. The fifth fumigation, made with trichloroacetonitrile at 2 pounds per 1000 cubic feet, 6-hour exposure, killed all the test insects. It appeared that single apartments can be safely fumigated without vacating the entire building, provided certain precautions are observed. A steady breeze carried the vapor into and across the hall during the exposure and ventilation periods. Vapor penetrated to the rooms directly below in sufficient quantities to necessitate evacuation of these rooms. During the sixth fumigation, using the 50–50 mixture at 1.5 pounds per 1000 cubic feet, the wind was in the opposite direction, and no difficulty was experienced with stray vapor during the 6-hour exposure period or ventilation period. All but a few insects in one location were killed. The last fumigation, made in four rooms of a modern building with cement floors and walls, using the 50–50 mixture at 1 pound per 1000 cubic feet and a 17.5-hour exposure, gave a complete kill of the test insects including German roaches. Aeration was rapid, and no discomfort was experienced by any of the occupants of the building during or after the fumigation.

On several occasions in the course of the foregoing fumigations, the writer deliberately exposed himself to higher concentrations of the vapor and for longer periods of time than would be necessary in commercial practice, in order to report extreme effects. Without a mask the vapor was irritating and painful to the eyes and mucous membranes and strong whiffs caused nausea. Using a mask in houses being opened for ventilation, an exposure of 10 to 15 minutes caused a burning sensation in the scrotum. This painful effect can be avoided by leaving the house after a few windows are opened (in about 5 minutes) and returning a little later to finish the job. Contact of both liquids with the skin caused a transitory tingling sensation without subsequent injury.

The results of those fumigations indicate that both trichloroacetonitrile and the 50–50 mixture can be used for house fumigations at a reasonable dosage, even for 6-hour fumigations. Aeration is so rapid that a house fumigated during the day may be safely reoccupied within a few hours, thus eliminating the necessity for overnight fumigations, which are advocated for present commercial fumigants. Both fumigants tested by the writer are easily handled and used, there is no danger of injuring any furnishings, and the severe warning property makes accidental poisoning improbable.

SUMMARY AND CONCLUSIONS.—Trichloroacetonitrile and a 50–50 mixture of trichloroacetonitrile and acrylonitrile were tested for use in household fumigation. Both are highly toxic to insects but not highly dangerous to warm-blooded animals. They are colorless liquids, volatile at room temperature.

Tests made in a 740 cubic foot fumigation chamber demonstrated that trichloroacetonitrile and the 50–50 mixture are more effective at 80° than at 60° F., that moist conditions prolong the required aeration period several hours, and that an increase of the moisture content of furnishings within a day or two after the fumigation may cause eye irritation after the eye test has become negative under dry conditions.

The results of several house fumigations indicate that trichloroacetonitrile is pe-

culiarly useful for this purpose. Because it is very toxic to insects, penetrates well, an airs out rapidly, it is possible to fumigate a house during the day, ventilate for a few hours and admit the occupants the same night. Since it is a lachrymator, there is practically no danger from its use because persons cannot tolerate fatal concentrations.

It is desirable and necessary to wear a gas mask while working with these nitriles. A burning sensation in the scrotum may result from prolonged exposure to the vapor of trichloroacetonitrile. This unpleasant effect on the operator can be avoided by taking simple precautions during application and aeration.

In tight buildings, a dose of 2 pounds per 1000 cubic feet for 6 hours, or 1.5 pounds for 12 hours, should be adequate even for resistant clothes moths and carpet beetles.

Acrylonitrile may be used successfully in 50–50 mixture with trichloroacetonitrile for house fumigations. Slightly higher concentrations or longer exposures may be necessary where this mixture is used, particularly when clothes moths and carpet beetles are present. The same routine and precautions should be observed with this mixture as those which are outlined for trichloroacetonitrile.—9-15-43.

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Toxicity of Anabasine to the Citrus Thrips

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Anabasine, $C_{10}H_{14}N_2$, is a colorless, liquid alkaloid, which is an isomer of nicotine. It is very stable, very soluble in water, and also soluble in all organic solvents. It was synthesized in the United States by Smith (1929), who called his product neonicotine because of its close resemblance to nicotine. The compound was later extracted by Orékhoff (1929) in Russia from *Anabasis aphylla* L., a plant in the family Chenopodiaceae. Anabasine was also extracted by Smith (1935) from *Nicotiana glauca* Grah., a solanaceous shrub which occurs commonly in the southwestern part of the United States.

Roark (1941) has published the most complete summary of information on anabasine. The greatest reported toxicity from anabasine has been against species of aphids, some of which are more readily killed by it than by nicotine. It is reported that the toxicity of anabasine toward mosquitoes increases with an increase of temperature. The only record found of its use against thrips was against *Thrips tabaci* Lind., for which purpose anabasine sulfate (1:400) was not highly effective.

A considerable amount of experimental work has been done by the writer at Whittier, Calif., with the anabasine alkaloid (nearly 100 per cent pure) and with anabasine sulfate[1] (containing about 40 per cent anabasine) against the citrus thrips, *Scirtothrips citri* (Moulton).

PROCEDURE.—The thrips were reared and the tests made in cells described by Munger (1942). The work was done in a room maintained at a temperature of 86° F. and a relative humidity of 50 per cent. The water solutions to be tested were placed in the chamber of a glass pipette which was drawn out to a fine capillary. As the solution dripped from the end of the capillary, it was distributed evenly over the upper surface of a lemon leaf (sealed into a Munger cell) in a droplet pattern. The flow of each material through the capillary was calibrated in terms of

[1] The material was purchased as anabasine sulfate from the Amtorg Company in 1933. The anabasine alkaloid was made from this material.

Table 1.—Toxicity of water solutions of anabasine and anabasine sulfate to adult citrus thrips.

Sugar per Liter Gms.	Dosage per Leaf Ml.	Age of Residue at Start of Test-Days	Per Cent Mortality in Days			
			1	2	3	4
		Tests with anabasine alkaloid solution				
		At 1:1000				
None	0.2	0	—	100	—	—
		2	29	60[1]	—	—
9.9	0.2	0	91	100	—	—
			—	100	—	—
		1	94	100	—	—
		3	89	100	—	—
		5	—	—	90[2]	—
	0.25	0	90	100	—	—
		At 1:1500				
5.8	0.25	0	99	100	—	—
		At 1:2000				
9.9	0.3	0	57	67	77	78
		Tests with anabasine sulfate solution (40 per cent anabasine)				
		At 1:800				
4.25	0.25	0	91	100	—	—
		2	93	98	98	100
	0.3	0	—	100	—	—
			100	—	—	—
		2	—	93	100	—
		At 1:600				
None	0.3	0	—	100	—	—
			—	100	—	—
		2	98	99	100	—
		5	94	95	97	99
Checks	—	—	—	—	—	1.7

[1] This test was terminated on the second day.
[2] This test was terminated on the third day.

ml. per minute, and the period of dripping determined the dosage for each leaf.

When the deposits had dried, the adult insects in the rearing cells were lightly chloroformed and were transferred to the test cells by means of a camel's-hair brush. This has been the regular procedure in the technique of rearing thrips and does not seem to interfere with development. Thrips stupefied by refrigeration reacted in the same way to anabasine as those stupefied by chloroform. The number of thrips placed in each cell ranged from 20 to 50, and averaged 37. In an effort to eliminate any variability between different reared lots of thrips, equal numbers of insects from different lots were placed in each test cell.

RESULTS OF INITIAL EXPERIMENTS.—The results of the first tests are presented in table 1. Tests were also run with anabasine alkaloid solution against thrips larvae, which appeared to be fully as susceptible to this material as the adults.

ACTION OF ANABASINE ON CITRUS THRIPS.—Tests were conducted by placing cover glasses coated with anabasine-sugar residues in cages containing citrus thrips, so that the thrips would crawl readily over them. After 24-hour exposures the glasses were removed and examined microscopically. The spray deposits showed no trace of the feeding pits characteristic of thrips feeding on certain sugar-bait residues. This indicates that citrus thrips do not feed on the anabasine-sugar residue, and the material probably acts as a contact insecticide or fumigant. However, sugar or some other added material gives body to the deposit, and should retard the loss of the toxic material.

Next, 0.3 ml. of the anabasine alkaloid-sugar solution (anabasine 1:1000) was applied, as in the regular tests, to the upper surface of each of the lemon leaves. Thin tissue paper was then sealed in immediate contact with the dried residue on the leaves, and citrus thrips adults were

placed in the cages on the tissue. The thrips immediately exhibited the typical reactions to anabasine. After 24 hours' exposure, 99 per cent were dead. This test was repeated with anabasine sulfate solution (1:600) and sugar. After 24 hours exposure, 92 per cent of the thrips were dead. Thrips placed in cells on tissue sealed to untreated leaves showed none of the symptoms associated with anabasine.

In order to obtain additional data on the nature of the toxic action of anabasine the following tests were conducted: Three-tenths of a milliliter of anabasine alkaloid-sugar solution (anabasine 1:1000) was applied to 30 square centimeters of the ceiling of each cell and, when dry, was shielded from contact by the thrips with tissue paper sealed closely to the treated ceiling. The anabasine residue was a half-inch removed from the leaf surface upon which the thrips were feeding. After a period of 4 days all thrips were alive and active. This test was repeated, except that anabasine sulfate (1:600) and sugar was applied to the cell ceilings. After 24 hours 85 per cent of the thrips were alive.

These observations indicate that there is a definite fumigating action from the dry anabasine-sugar residues, in addition to a purely contact effect which may exist, but that its range of effectiveness is less than a half-inch.

Observations were made on citrus thrips that had been stupefied with light doses of chloroform and then placed immediately, using a camel's-hair brush, in rearing cells in which there were leaves with dry deposits of anabasine or anabasine sulfate. Within a few minutes after coming into contact with the anabasine deposits many of the thrips underwent convulsions, control of muscular movement being lost. After 6 to 10 minutes of convulsions the thrips became paralyzed, except for slight movements of legs and antennae and death ensued within a day or two, often within a few hours. The material seemed to affect the larvae and adult males more rapidly than it did the adult females.

Soon after the beginning of exposure to anabasine, the great majority of larvae exuded a viscid fluid from the anus as the latter contracted the substratum. This fluid appeared to dry quickly and seal the tip of the abdomen to the supporting surface, preventing further travel by the larva.

SUMMARY.—Anabasine alkaloid at strengths of 1:2000 to 1:1000, and anabasine sulfate (40 per cent anabasine) at strengths of 1:800 to 1:600, both with and without sugar, showed high toxicity to the citrus thrips in laboratory experiments carried on at Whittier, Calif. Sugar or some other added material is probably of value in retarding the loss of the toxic material.

The citrus thrips do not seem to feed on the anabasine-sugar residues. The material appears to act by contact and by fumigation. Although citrus thrips do not need actually to come in contact with the anabasine residue to be killed, the indicated range of the fumigation effect is less than a half-inch.

On coming under the influence of the anabasine, the thrips underwent convulsions, followed by paralysis within 9 to 14 minutes after the exposure to anabasine. —11-13-43.

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The Fumigation of Camellia and Azalea Cuttings with Methyl Bromide

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Camellias and azaleas are propagated extensively in south Alabama by means of cuttings. Azalea cuttings are usually taken in May and are ready to remove from the sand benches in July. Camellia cuttings are usually taken during July and August and are ready to remove from the sand in October or November. Under greenhouse conditions azalea cuttings often become seriously infested with the red mite, *Paratetranychus ilicis* McG., and greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché). In addition to *P. ilicis*, camellia cuttings may be infested from the stock plant with camellia scale, *Lepidosaphes camelliae* Hoke, and tea scale, *Fiorinia theae* Green. Dense populations of these pests cause defoliation of the cuttings and consequent failure to root. Even though cuttings survive the insect damage, the infestations remain after transplanting, causing unhealthy and undesirable plants. Since the fumigation of camellia and azalea plants with methyl bromide for the control of these pests proved successful (English 1943), investigations were undertaken to determine if cuttings from these plants would be injured by the dosages of methyl bromide necessary for insect control.

General Procedure.—The equipment and general procedure were essentially the same as that used in the previous experiments with plants (English 1943). Cuttings were clipped from the stock plants and placed in paper bags for transportation to the fumigation chamber. They were then transferred to peck baskets and placed in the chamber, the floor of which had been sprinkled with water to provide a relative humidity of about 90 per cent. When the desired constant-temperature inside the chamber had been established the gas was introduced. A centrifugal blower was allowed to run throughout the entire period of pre-heating and fumigation.

After fumigation, azalea cuttings were dipped in water and prepared for planting by pinching out the succulent tips and stripping off all but three or four leaves near the top. Camellia cuttings were not dipped in water as this proved to be detrimental to some varieties, but were stripped to two leaves for planting. All of this work was carried out in the shade. The cuttings were planted according to nursery custom in moist sand in the greenhouse benches. Greenhouses used for propagating were thoroughly whitewashed to reduce the intensity of the sunshine. Subsequent care of the cuttings were left to an experienced greenhouse man.[1] When practically all of the cuttings had rooted, they were taken up and records on survival and rooting made.

Preliminary Tests.—Fifty cuttings of each of 58 varieties of azaleas were fumigated with a dosage of 2 pounds of methyl bromide per 1000 cubic feet at a temperature of 80° F., using exposures of 1, 1.5, and 2 hours. Since the cuttings of Coral Bell and Salmon Beauty were practically all killed, these were omitted from a summary of the data given in table 1.

Table 1.—Data on the survival of azalea cuttings fumigated with methyl bromide at the rate of 2 pounds per 1000 cubic feet at a temperature of 80° F.

Exposure Hours	Mean Per Cent Survival[1]	Varieties with 80 to 100 Per Cent Survival
0	93.9	52
1.0	94.4	51
1.5	85.5	43
2.0	70.7	25

[1] Fifty-six varieties in each test. Least significant difference, 8.2 per cent, odds 20:1.

An exposure of 1 hour had no effect on the mean percentage survival; an exposure of 1.5 hours caused some loss, although not prohibitive; while the 2-hour exposure caused losses which probably would not be accepted by nurserymen. Varities sustaining more than 20 per cent (check basis) loss from the 1.5-hour exposure were, in addition to Coral Bell and Salmon Beauty, Criterion, Hinomayo, Flame,

[1] The authors are particularly indebted to Semmes Nurseries for supplying cuttings and greenhouse facilities for this work.

Cattleya, Sweet Briar, Salmon Queen, Outside White, Indica Alba, Lilacina, Apple Blossom, and Daphne Salmon.

Fifty cuttings of each of 40 varieties of *Camellia japonica* and five of *Camellia sasanqua* were fumigated with a dosage of 2 pounds of methyl bromide per 1000 cubic feet at 80° F. for exposures of 1.5, 2.0, and 2.5 hours. There was no significant loss from the 1.5-hour exposure, slight loss from the 2-hour exposure, but rather severe loss from the 2.5-hour exposure (Table 2). Varieties which sustained more than 20 per cent (check basis) loss from the 2-hour exposure were, Jarvis Red, Candidissima, Rose Emry, Empress of India, Brown's Red, Comte de Gomer, Duc de Bretange, Kellingtonia, No. 1 Sasanqua, No. 2 Sasanqua, a pink Sasanqua, and a white Sasanqua.

Table 2.—Data on the survival of camellia cuttings fumigated with methyl bromide at the rate of 2 pounds per 1000 cubic feet at a temperature of 80° F.

Exposure Hours	Mean Per Cent Survival[1]	Varieties with 80 to 100 Per Cent Survival
0	84.4	34
1.5	80.4	35
2.0	76.0	26
2.5	54.8	14

[1] Forty-five varieties in each test. Least significant difference 9.9 per cent, odds 20:1.

EQUIVALENT DOSAGES AND EXPOSURES AT VARIOUS TEMPERATURES.—Since sufficient data were at hand (English 1943) to estimate equivalent fumigation schedules effective against the pests under consideration, a series of tests was arranged for temperatures of 80, 90, 100, and 110° F., in an effort to establish optimum conditions for the fumigation of cuttings.

Eighteen varities of azaleas were selected for these tests. The selection included some of those which appeared to be more susceptible to methyl bromide and some which were resistant. Inasmuch as Coral Bell and Salmon Beauty were killed by all of the fumigation schedules they were omitted from a summary of the data in table 3. The most outstanding result of this experiment was that a dosage of 0.5 pound at all the temperatures significantly reduced the survival of cuttings. Evidently the longer exposures required in the use of this dosage was a factor affecting survival. There was no significant difference between the other treatments and there was no significant difference between six of the treatments and the checks.

Fourteen varieties of camellias were selected for similar tests but the exposures used were a little longer. Fifty cuttings of each variety were used in each test. From the results (Table 4) it is evident that dosages and exposures at 100 and 110° F. caused significant reductions in the mean percentage survival. The use of a dosage of 0.5 pound, which was found undesirable on azalea cuttings, was also undesirable on camellia cuttings.

FUMIGATION UNDER FAVORABLE CONDITIONS.—Although the results of experiments to establish optimum conditions were not clear cut, it was concluded that a dosage of 2 pounds at a temperature of 90° F. was suitable. The use of this dosage and temperature provides effectiveness with a comparatively short exposure and permits fumigation in the summer without cooling the chamber artificially. Both of these factors are of practical concern.

Table 3.—Data on the survival of azalea cuttings fumigated with approximately equivalent schedules at various temperatures.

Dosage Lbs./1000 Cu. Ft.	Exposure Hours	Temperature °F.	Mean Per Cent Survival[1]
2.0	1.5	80	97.7
1.0	3.0	80	91.4
0.5	5.0	80	89.7
Check			99.4
2.0	1.0	90	96.5
1.0	2.0	90	95.6
0.5	4.0	90	78.2
Check			99.4
2.0	0.75	100	93.6
1.0	1.5	100	95.6
0.5	3.0	100	86.9
Check			98.7
2.0	0.5	110	95.2
1.0	1.0	110	91.6
0.5	2.0	110	90.2
Check			98.5

[1] Sixteen varieties in each test. Least significant difference, 6.1 per cent, odds 20:1.

Twenty-two varieties of azaleas were chosen for this experiment. The list was made up of the more important varieties and included some of those which appeared to be susceptible to methyl bro-

mide in the early experiments. One hundred cuttings of each variety were used in each test and they were given exposures of 1.0, 1.25, and 1.5 hours. After a temperature of 90° F. had been established inside the chamber, the cuttings were allowed to pre-heat for 0.5 hour at this temperature before the gas was introduced. There was slight reduction in the mean percentage survival with the 1.5-hour exposure, only (Table 5). The lowest survival with this exposure was 75 per cent, sustained by the variety Sunstar. There was slight reduction in the mean percentage of the survivals that rooted after an exposure of 1.5 hours. Most of this retardation of rooting was sustained by the varities Sunstar and Flame. The latter is slow to root anyhow, as only 55.5 per cent of the survivals were rooted in the untreated lot and 29.9 per cent rooted in the lot exposed for 1.5 hours, at the time the cuttings were taken up for examination. There was no significant retardation of rooting from exposures of 1.0 and 1.25 hours.

Table 4.—Data on the survival of camellia cuttings fumigated with approximately equivalent schedules at various temperatures.

Dosage Lbs./1000 Cu. Ft.	Exposure Hours	Temperature °F.	Mean Per Cent Survival[1]
2.0	2.0	80	42.3
1.0	4.0	80	46.3
0.5	6.0[2]	80	57.2
Check			66.0
2.0	1.5	90	60.0
1.0	3.0	90	54.4
0.5	5.0	90	49.1
Check			63.2
2.0	1.0	100	42.6
1.0	2.0	100	44.5
0.5	4.0	100	16.3
Check			48.2
2.0	0.75	110	34.0
1.0	1.5	110	14.0
0.5	3.0	110	29.6
Check			62.5

[1] Fourteen varieties in each test. Least significant difference, 11.4 per cent, odds 20:1.
[2] Exposure should have been 7 hours for approximate equivalence.

Cuttings from 18 varities of camellias were used for exposures of 1.0, 1.25, and 1.5 hours, with a dosage of 2 pounds of the fumigant at a temperature of 90° F. Fifty cuttings of each variety were used in each test. There was no significant difference in the survival of the fumigated and unfumigated cuttings (Table 6). There was some retardation of root development caused by the 1.5-hour exposure, but none by the 1.0- and 1.25-hour exposures. Examination of the cuttings showed no camellia scale present on any of the fumigated lots, whereas several varieties in the check lot were infested.

FUMIGATION OF ROOTED CUTTINGS.—After rooting in greenhouse benches, azalea and camellia cuttings are transplated to cold frames. This offers an excellent opportunity to load the plants in a chamber for fumigation without much additional labor.

Twenty-one varieties of azaleas were selected for tests. These included the more important varieties of both the Indica and Kurume groups, with the exception of Coral Bell and Salmon Beauty. When the cuttings were rooted they were taken from the benches, divided into three lots, and heeled in flats of moist sand. Since azalea cuttings are usually removed from the greenhouse in mid-summer they were fumigated at 90° F., using a dosage of 2 pounds of methyl bromide per 1000 cubic

Table 5.—Data on the survival of azalea cuttings after fumigation with methyl bromide at the rate of 2 pounds per 1000 cubic feet at a temperature of 90° F.

Exposure Hours	Mean[1] Per Cent Survival	Mean Per Cent of Survivals Rooted
0	98.7	93.2
1.0	97.7	93.1
1.25	97.3	91.1
1.5	94.4	88.7

[1] Twenty-two varieties in each test. Least significant difference 4.17 per cent, odds 20:1.
[2] Least significant difference, 2.74 per cent, odds 20:1.

Table 6.—Data on the survival of camellia cuttings after fumigation with methyl bromide at the rate of 2 pounds per 1000 cubic feet at a temperature of 90° F.

Exposure Hours	Mean[1] Per Cent Survival	Mean Per Cent[2] of Survivals Rooted
0	80.8	83.3
1.0	79.0	86.8
1.25	81.1	83.9
1.5	77.9	67.1

[1] Eighteen varieties in each test. No significant difference between means.
[2] Least significant difference between means, 2.43 per cent, odds 20:1.

feet with exposures of 1.25 and 1.5 hours. From 30 to 90 plants of each variety were used for each treatment and a similar lot was planted without fumigation. The survival of all lots was almost perfect. The lowest mean survival of any lot was 99.5 per cent, and the lowest survival of any one variety was 93.3 per cent.

When these plants were fumigated they were heavily infested with greenhouse thrips and some varieties had lost most of their leaves. After fumigation and planting, 100 leaves were taken from each lot at intervals for 10 weeks for examination. No thrips were found on the lot exposed for 1.5 hours, indicating that all stages, including the eggs, had been killed. A few eggs survived the 1.25-hour exposure. The rapid growth of the fumigated plants was in striking contrast to that of the unfumigated plants where thrips continued to cause serious damage.

Several lots and a number of varieties of rooted camellia cuttings were fumigated in flats of moist sand. Since these plants are usually removed from the greenhouse for transplanting in the fall, when atmospheric temperatures are lower than in the summer, fumigation was carried out at 80° F. There was no significant difference between the mean percentage survival of treated and untreated lots. (Table 7).

Table 7.—The survival of rooted camellia cuttings after fumigation with methyl bromide at the rate of 2 pounds per 1000 cubic feet at a temperature of 80° F.

Exposure—Hours	0	2.0	0	2.25	0	2.5
No. Varieties	40	40	18	18	14	14
Per Cent Survival[1]						
Mean	99.9	99.8	99.3	96.9	96.9	89.9
Minimum Any Variety	98.2	97.8	96.0	81.8	91.1	65.5

[1] No significant difference between treated and untreated lots.

SUMMARY.—Tests with cuttings from 58 varieties of azalea and 45 varieties of camellia showed that most of them could be safely fumigated with methyl bromide at dosages necessary for the control of red mite, thrips, camellia scale, and tea scale. Cuttings from the azalea varieties Coral Bell and Salmon Beauty apparently cannot be satisfactorily fumigated with methyl bromide. In a series of approximately equivalent dosages and exposures at various temperatures, the long exposures required with a dosage of 0.5 pound per 1000 cubic feet was detrimental to the survival of cuttings. Rooted cuttings placed in flats of moist sand were also fumigated when removed from the greenhouse for transplanting. Since several thousand cuttings can be fumigated in a relatively small chamber this practice affords nurserymen a cheap method of producing clean plants. Schedules of 2 pounds of methyl bromide per 1000 cubic feet with an exposure of 1.25 hours at 90° F. and 2 pounds for 2.25 hours at 80° F. meet the practical requirements.

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Sprays for the Control of Ticks about Houses or Camps

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The term "wood tick," as commonly used, is applied to several species of ticks of similar habits. Included in this group are the Rocky Mountain spotted fever tick, *Dermacentor andersoni* Stiles, the American dog tick, *Dermacentor variabilis* (Say), the lone star tick, *Amblyomma americanum* (L.), and the black-legged tick, *Ixodes scapularis* Say. The first two are the principal vectors of Rocky Mountan spotted fever and are also of some importance in the transmission of tularemia. The lone star tick is believed to be of minor importance in disease transmission, but it causes extreme annoyance as a pest in the localities where it abounds. The black-legged tick does not bite man so readily as do the others, but when it does attach it is more difficult to remove and the bite is more painful than that of the others. All four species are troublesome as pests of livestock.

The writers have had occasion to investigate the use of sprays against three of the species mentioned above and believe that in many instances this method of control would be of value. At the present time military activities are bringing large numbers of men into tick-infested brush, and all information on methods of tick control should be made available. Ordinarily wood tick infestations extend over such large areas that complete control would be impractical, but the portions of such areas in which men are most concentrated, and particularly the region about their sleeping quarters, could be kept relatively free of ticks by the use of a satisfactory spray.

In keeping an area free of ticks for any length of time, even the most effective sprays would have to be applied at fairly frequent intervals, probably once a week, as the area would be subject to constant reinfestation by ticks emerging from hibernation, hatching or molting from the preceding stage, or migrating from adjacent untreated areas.

NICOTINE SULFATE.—In 1938 Bishopp & Smith stated that many of the American dog ticks on an infested area could be killed by applying a spray of 1 part of nicotine sulfate (40 per cent nicotine), 1 part of soap, and 288 parts of water. Further investigations have shown that a considerable number of the ticks recover from this spray, but the reduction in ac-

Table 1.—Reduction in abundance of ticks on ground and vegetation after spraying with sodium fluoride-nicotine sulfate.

Date		In Sprayed Area		In Check Area	
		Number of Ticks of the Specified Type Collected and Per Cent of the Original Infestation[1]			
		Dermacentor variabilis, adults			
1941		*Number*	*Per Cent of original*	*Number*	*Per cent of original*
July	1	543	100	122	100
	2[2]	—		—	
	3	47	9	89	73
	5	6	1	48	39
	7	41	7	82	67
	10[2]	—		—	
	11	9	2	92	75
	14	26	5	41	34
	16	39	7	62	51
		Ixodes scapularis, adults			
1943					
Jan.	18	95	100	224	100
	23[2]	—		—	
	24	2	2	169	76
	25	10	11	150	67
	27	16	17	125	56
	30	30	32	155	69
Feb.	2	33	35	213	95
		Amblyomma americanum, adults			
1943					
June	8	19	100	30	100
	9[2]	—		—	
	10	1	5	45	150
	11	4	21	29	97
	14	5	26	45	150
	15[2]	—		30	100
	16	1	5	30	100
	17	0	0	30	100
	18	5	26	38	127
	21	3	16	20	67
		Amblyomma americanum, nmyphs			
1943					
June	8	425	100	364	100
	9[2]	—		—	
	10	19	4	389	107
	11	42	10	408	112
	14	69	16	470	129
	15[2]	—		334	92
	16	8	2	288	79
	17	4	1	238	65
	18	10	2	314	86
	21	5	1	232	64

[1] All ticks were released as collected.
[2] Date of spraying.

tive ticks following its use usually exceeded 90 per cent for 2 or 3 days. The spray is not injurious to vegetation, and if only a temporary reduction in tick abundance is required, as at an overnight camp site, the writers recommend its use, but would recommend that the nicotine sulfate content be increased to 1 part in 200.

SODIUM FLUORIDE AND NICOTINE SULFATE.—If an area is to be kept relatively free of ticks for a week or more, it is dedirable to use a spray from which the ticks will not recover. The material that the writers have found most effective for such a purpose contains 1.92 ounces of sodium fluoride, 0.64 fluid ounce of nicotine sulfate (40 per cent nicotine), and 0.125 ounce of neutral soap to 1 gallon of water. The sodium fluoride alone is slow in its action, but when it is combined with nicotine sulfate the knock-down is quick and the effect permanent. The material burns foliage to some extent, and should not be used on valuable plants. Its use in woodlands would not be objectionable, as only the low vegetation need be sprayed, and if the terrain is used by troops the upper canopy would conceal any change in foliage color from aerial observation. Grasses are burned to some extent, but sheep have been observed to feed voluntarily on the sprayed grass without apparent injury.

Typical examples of the reduction in the abundance of various types of wood ticks following the use of the spray are shown in table 1. The abundance in comparable check areas is also shown. Collections were made by dragging a flannel cloth slowly over the entire area, removing the ticks at intervals of 1 minute.

In the test with *Dermacentor variabilis* the ticks were concentrated along a grassy roadside. Here 13.5 gallons of spray were applied to a strip 2023 feet long by 4 feet wide, or at the rate of 73 gallons per acre. In the test with *Ixodes scapularis* the ticks were also concentrated along a road, but the roadside vegetation included bushes as well as grass. Ten gallons of spray were applied to a strip 1068 feet long by 4 feet wide, or at the rate of 102 gallons per acre. The areas infested by *Amblyomma americanum*, adults and nymphs, were in a woodland with a moderate amount of underbrush and some grass. Ten gallons of spray were applied to an area 50 feet square, or at the rate of 174 gallons per acre. It will be noted that in each case the area was of such size and shape as to be subject to as much reinfestation by migrating ticks as would ever be encountered. In the test with *Amblyomma americanum* a hard rain fell about 10 hours after the original spraying, and there were 5 rainstorms during the 12 days of observations.

In each test a considerable reduction in tick abundance followed the application of the spray. Reinfestation of the sprayed areas was more rapid early in the season, when abundance was increasing in the check areas and elsewhere, than it was after the seasonal peak of abundance had been passed. In the test with *Dermacentor variabilis* the peak of seasonal abundance had been passed when the spray was applied; in the test with *Ixodes scapularis* abundance was about at its peak; and in the test with *Amblyomma americanum* adult abundance was at or near its peak and nymphal abundance had passed its peak.

A single field test of sodium fluoride and nictine sulfate against chiggers, or redbugs, *Acariscus masoni* Ewing, was conducted with very discouraging results. No accurate method of measuring chigger abundance was available, but observations in the area revealed approximately equal numbers of active chiggers, before and after spraying, on dead twigs and other debris lying on the ground.

DINITROORTHOCYCLOHEXYLPHENOL.—Laboratory tests with two proprietary insecticides containing dinitroorthocyclohexylphenol indicated that one was very effective against *Dermacenter variabilis*, whereas the other was not. The addition of nicotine sulfate increased the speed of action. In field tests with the effective preparation (*Dow's DN Dry Mix Wettable*) results very slightly inferior to those with sodium fluoride were obtained. In field tests in which a mixture of 1.28 ounces of DN, 0.64 fluid ounce of 40 per cent nicotine sulfate, and 0.125 ounce of soap per gallon of water were used, the number of ticks in the sprayed area for 5 to 6 days after spraying ranged from 2 to 15 per cent of the original number, whereas the number in the check area ranged from 35 to 71 per cent. The spray burned the foliage to some extent.

PYRETHRUM.—Sprays made by emulsi-

fying ordinary kerosene extracts of pyrethrum were not effective in field tests against *Dermacentor variabilis*, but sprays containing purified pyrethrum extract, 20 per cent pyrethrins, and an activator, isobutylundecyleneamide (in 930), were as effective in field tests as the sodium flouride-nicotine sulfate combination against *Ixodes scapularis* adults and *Ambylomma americanum* nymphs and adults. Against *Ixodes scapularis*, a dilution of 1 ml. of pyrethrum extract and 0.4 ml. of *IN 930* to 1 gallon of water was effective, but against *Amblyomma americanum* it was necessary to use a strength of 2.6 ml. of pyrethrum extract and 1 ml. of *IN 930* to 1 gallon of water. In each case 0.125 ounce of soap per gallon was used. The sprays were applied, as was the sodium fluoride spray, at from 100 to 175 gallons per acre according to the density of the underbrush. The spray caused no appreciable damage to foliage. Although pyrethrum is not at present available for civilian use, these data are given for the benefit of military units that might be able to get supplies of the material, and require a spray noninjurious to foliage.

OTHER INSECTICIDES.—Sprays containing emulsions of pine oil and diphenylamine in benzol were not satisfactory against adults of *Dermacentor variabilis* in field tests.

SUMMARY.—A spray containing 1 part of 40 per cent nicotine sulfate in 200 parts of water reduced the abundance of the American dog tick, *Dermacentor variabilis*, on vegetation by about 90 per cent for 2 or 3 days and was not injurious to the vegetation, but many of the ticks recovered. The material is recommended where only temporary reductions are required.

A spray containing 1.5 per cent of sodium fluoride and 0.5 per cent of nicotine sulfate gave a quick knock-down and actual kill, but was injurious to foliage. It was effective against *Dermacentor variabilis*, *Ixodes scapularis*, and *Amblyomma americanum*, but not against the chigger, *Acariscus masoni*. It is recommended for use where there are no valuable plants and when permanent reductions in tick abundance are desired.

Some preparations of dinitroorthocyclohexylphenol were almost as effective against *Dermacentor variabilis* as sodium fluoride, but were equally injurious to foliage.

A spray containing 2.6 ml. of purified pyrethrum extract in 1 gallon of water with an activator was as effective as sodium fluoride and nicotine sulfate against *Amblyomma americanum*, and even weaker dilutions were effective against *Ixodes scapularis*. The material was not injurious to foliage, but is not at present available for civilian use for this purpose.

With each of the three preceding materials an immediate reduction in tick abundance of more than 90 per cent was obtained. The rapidity of reinfestation of the sprayed area varied with the numbers of molting and migrating ticks. In most cases the reduction was at least 75 per cent for a week.—9-18-43.

LITERATURE CITED

Bishopp, F. C., and C. N. Smith. 1938. Combating the American dog tick, carrier of Rocky Mountain spotted fever in the Central and Eastern States. U.S.D.A., Bur. Ent. and Plant Quar. Circ. E-454.

JAMES ZETEK

One of our older members, long a resident of the Canal Zone, sends greetings to the Secretary which are doubtless meant for all our members, as follows: "My warmest and best as always. We are too busy for comfort. Hope you are in better conditions than we.

Sincerely,
Zetek.

(Address James Zetek, Drawer C, Balboa, Canal Zone, Panama.)

New Distribution Records for the Mosquitoes of the Southeastern United States in 1943

WOODROW W. MIDDLEKAUFF,[1] and STANLEY J. CARPENTER,[2] *Fourth Service Command Medical Laboratory, Fort McPherson, Georgia*[3]

The continuation of the United States Army's mosquito survey program, now in its second season, continues to add materially to our knowledge of the abundance and distribution of the mosquito fauna of the seven states in the Southeastern United States which comprise the Fourth Service Command. A considerable number of new state records as well as new locality records have been added this year, and in addition one new species of *Aëdes* has been collected in Florida and will be described at a later date.

Since the state of Louisiana is no longer under the jurisdiction of this Command, the Fourth Service Command is now composed of the following states: Florida, Georgia, Alabama, Mississippi, Tennessee, North Carolina, and South Carolina.

Several Army installations scattered throughout the above mentioned states submit weekly collections of mosquito adults and larvae to this laboratory for identification or confirmation. The fundamental purpose underlying these collections is to keep a constant check on the abundance of *Anopheles quadrimaculatus* at the various Army posts.

Approximately 142 stations submitted mosquitoes for identification, and from January through October the number of specimens identified at this laboratory totaled 540,748 adults and 151,891 larvae. All of the following records are based upon these identifications. A check list of the mosquitoes from this area is given in table 1, which is modified from King *et al.* (1942). Our accumulated records to date are included in this table.

Many of the following collections were too numerous to list individually so they are lumped into weekly or even monthly periods wherever this was thought to be advantageous. The collections are listed under the respective species according to type and are indicated by the following symbols: (T) = light trap (New Jersey type); (S) = resting station such as culvert, nail keg, barn, etc.; (B) = biting; (R) = specimens reared from larvae; (L) = larvae. These types of collections should be self-explanatory, but it may be well to mention that, as used by us, biting records do not necessarily mean that the specimen was caught in the act of blood-sucking. This should be noted since a few males are reported in biting collections.

[1] Captain, Sanitary Corps, Army of the United States.
[2] Major, Sanitary Corps, Army of the United States.
[3] It is desired to express appreciation to the following officers for assistance and encouragement: Colonel Sanford W. French, M.C., Colonel Charles G. Souder, Colonel Dwight M. Kuhns, M.C., and Colonel M. J. Blew, Sn.C., and also to Lieutenants James Toffaleti, Louis Roth, Harry Hoogstraal; Corporal John Wanamaker; Corporal R. Chamberlain; Miss Leonora Peeples, SP-3; and Miss Jeanne Pryor, SP-3.

Table 1.—Genera and species of mosquitoes occurring in seven southeastern states comprising the fourth service command.

Genus and Species	Recorded in[1]						
	Fla.	Ga.	Ala.	Miss.	Tenn.	N. C.	S. C.
Aëdes							
aegypti	x	x	x	x	x	x	x
atlanticus	x	x	x	42	P	x	x
atropalpus	—	—	—	—	x	x	—
canadensis	x	42	42	x	x	x	x
cinereus	—	42	—	—	43	43	42
dupreei	x	42	x	42	43	x	x
fulvus pallens	x	x	42*	x	P	x	x
grossbecki	—	—	—	x	—	—	—
infirmatus	x	x	43	x	P	x	x
mitchellae	x	x	x	42	—	x	42
sollicitans	x	x	x	x	—	x	x
sticticus	x	x	42	42	x	x	42
stimulans	—	—	—	x	—	—	—
taeniorhynchus	x	x	x	x	—	x	x

GENUS AND SPECIES	RECORDED IN						
	Fla.	Ga.	Ala.	Miss.	Tenn.	N. C.	S. C.
thibaulti	43	x	x	x	P	x	43
tormentor	x	x	x	x	—	43	x
triseriatus	x	x	x	x	x	x	x
trivittatus	—	x	—	—	42	42	—
texans	x	x	x	x	x	x	x
Anopheles							
albimanus	x	—	—	—	—	—	—
atropos	x	43	x	x	—	42	x
barberi	x	x	x	x	x	x	x
crucians bradleyi	x	42	x	x	—	43	x
crucians crucians	x	x	x	x	x	x	x
crucians georgianus	42	x	42	42	—	42	42
pseudopunctipennis	—	—	—	x	x	—	—
punctipennis	x	x	x	x	x	x	x
quadrimaculatus	x	x	x	x	x	x	x
walkeri	x	x	P	42	x	43	P
Culex							
apicalis	x	x	x	42	x	x	x
atratus	42	—	—	—	—	—	—
bahamensis	x	—	—	—	—	—	—
erraticus	x	x	x	x	x	x	x
nigripalpus	x	x	x	43	43	—	x
peccator	x	x	x	x	x	x	x
pilosus	x	x	x	42	—	x	x
pipiens	—	42	42	—	x	x	42
quinquefasciatus	x	x	x	x	x	x	x
restuans	x	x	x	x	x	x	x
salinarius	x	x	x	42	42	x	x
tarsalis	43	43	43	43	42	—	43
Culiseta							
inornata	x	42	x	x	42	x	x
melanura	x	x	x	42	43	x	x
Deinocerites							
cancer	x	—	—	—	—	—	—
Mansonia							
perturbans	x	x	x	42	x	x	x
titillans	x	—	43	—	—	—	—
Megarhinus							
rutilus	x	x	—	—	—	—	—
septentrionalis	—	x	x	x	x	x	x
Orthopodomyia							
alba	—	—	x	43	—	—	43
signifera	x	x	x	x	x	x	x
Psorophora							
ciliata	x	x	x	x	x	x	x
confinnis	x	x	x	x	x	x	x
cyanescens	—	42	x	x	43	—	43
discolor	x	x	x	x	x	x	42
ferox	x	x	x	x	x	x	x
horrida	—	42	42	x	x	42	43
howardii	x	x	43	x	x	x	x
pygmaea	x	—	—	—	—	—	—
varipes	x	x	x	x	x	42	43
Uranotaenia							
lowii	x	42	42	42	—	43	x
sapphirina	x	x	x	x	x	42	x
Wyeomyi							
mitchellii	x	—	—	—	—	—	—
smithii	—	—	x	—	—	x	x
vanduzeei	x	—	—	—	—	—	—
Total Species	52	50	49	50	38	48	49

[1] x—Recorded by King, Bradley, and McNeel, 1942.
42—Recorded by King, Roth, Toffaleti, and Middlekauff, 1943.
42*—Collected by J. N. Belkin.
43—New state records.
P—Species probably occurs.—King, Bradley, and McNeel, 1942.

Aëdes atlanticus D. and K.

At the present time the females of *A. atlanticus* cannot be distinguished from those of *A. tormentor*. The following adult records are therefore based upon an examination of the male genitalia.

MISSISSIPPI—Gulfport Field: (T) 1♂[2] June 25; 5♂[2] Aug. 6; 1♂ Oct. 11. Mississippi Ordnance Plant: (L) 1, Aug. 31; 5, Sept. 7. Keesler Field: (T) 1♂[2] Oct. 13.

Aëdes canadensis (Theob.)

GEORGIA—Thomasville Army Air Base: (T) 1♂, 3♀ May 5, 7; 1♀ May 12. Turner Field: (S) 1♀ March 26. Waycross Army Air Base: (S) 1♀ July 27.

Aëdes cinereus Meig.

TENNESSEE[1]—Municipal Airport Base Hospital: (T) 1♂[2] April 26-May 1; 1♂ May 3–8.

NORTH CAROLINA[1]—Camp Sutton: (T) 1♀ July 21.

Aëdes dupreei (Coq.)

GEORGIA—Camp Gordon: (T) 1♀ July 19. Hunter Field: (T) 1♀ July 26.

MISSISSIPPI—Columbus Army Flying School: (T) 1♂[2], 1♀ June 18. Gulfport Field: (T) 1♀ Sept. 24; 2♂[2], 1♀ Sept. 27–Oct. 1; 2♂ Oct. 11.

TENNESSEE[1]—Camp Tyson: (T) 1♂[2] July 28.

Aëdes fulvus pallens

ALABAMA—Sheffield (L) Aug. 30, 1942. Coll. J. N. Belkin.

Aëdes infirmatus D. and K.

ALABAMA[1]—Brookley Field: (S) 1♀ April 19. (L) 6, May 28; 1, Sept. 23. Napier Field: (T) 1♀ May 14.

Aëdes mitchellae (Dyar)

MISSISSIPPI—Gulfport Field: (T) 2♀ June 18, 21; 2♀ July 7; 4♀ July 14; 216♂, 60♀ Aug. 18–27; 1♂, 7♀ Oct. 4. (L) 21, Sept. 28, Oct. 2. Keesler Field: (L) 1, July 14; 3, Sept. 14; 34, Sept. 20–22. (T) 5♀ Aug. 23–27. Laurel Army Air Base: (T) 1♂, 1♀ Aug. 18; 1♀ Oct. 22.

SOUTH CAROLINA—Charleston Army Air Base: (B) 1♂ Aug. 25; 1♀ Aug. 27. Columbia Army Air Base: (T) 1♀ Aug. 13. Myrtle Beach Bombing Range: (T) 2♀ May 12, 14; 1♂, 9♀ May 31–June 4; 2♂ June 18; 47♀ July 12–16; 1♂, 11♀ July 19–23; 13♂, 22♀ July 26–30; 4♀ Aug. 4, 50♀ Aug. 9–13; 1♂, 16♀ Aug. 16–20; 2♂, 9♀ Aug. 30–Sept. 3. (R) 5♂ Sept. 19, 24; 3♂, 6♀ Sept. 29–Oct. 1. (B) 2♀ April 30; 1♀ May 13. (L) 27, Aug. 17. Walterboro Army Air Field: (L) 1, Sept. 30. 58th FTD-AAFCFS: (T) 1♀ May 14; 1♀ June 4; 10♀ July 2; 3♀ July 12; 1♂ July 23. (S) 1♂, 4♀ June 11; 16♀ June 18. Shaw Field: (T) 2♀ July 22. Stark General Hospital: (T) 9♀ April 12, 14; 1♀ April 23; 2♀ June 2; 2♀ June 7; 1♀ Aug. 21; 4♀ Aug. 23, 25; 2♀ Oct. 4. Georgetown: (T) 2♂ Aug. 21–27.

Aëdes sticticus (Meig.)

ALABAMA—Maxwell Field: (T) 13♂, 4♀ May 6–8; 1♀ May 10. Mobile: (S) 3♂, 2♀ April 19, 21. Tuskegee Army Air Field: (B) 1♀ May 27. (S) 6♀ May 12.

MISSISSIPPI—Columbus Army Flying School: (S) 2♀ April 7; 4♀ April 15; 10♀ April 20, 21; 2♀ May 5; 7♀ May 12–21; 1♀ June 2; 1♀ June 16. (T) 2♀ April 19. (B) 9♀ April 15; 7♀ April 20, 22; 2♀ May 12; 1♀ June 10. Greenville Army Air Field: (T) 1♂, 2♀ June 9, 11; 1♀ June 14; 1♀ June 21; 1♀ June 29. (S) 5♂, 4♀ April 28–29; 1♂, 2♀ June 7; 2♀ June 18. (B) 1♀ April 29. Greenwood Army Air Field: (S) 1♀ May 22; 1♀ June 11; 1♀ June 18. Jackson Army Air Base: (S) 1♂ April 28; 2♀ June 16. Camp McCain: (B) 17♀ April 22; 8♀ April 27; 1♀ June 11; 2♀ June 12. (S) 2♀ April 13; 2♂, 16♀ April 20; 1♂, 15♀ April 25–May 1; 2♀ May 5, 6; 2♀ June 9. (T) 1♀ June 11. Mississippi Ordnance Plant: (B) 1♀ April 28; 1♀ May 25; 1♀ June 7. (S) 2♀ April 28.

Aëdes thibaulti D. and K.

FLORIDA[1]—Marianna Army Air Base: (T) 1♂[2] April 7.

SOUTH CAROLINA[1]—Myrtle Beach Bombing Range: (B) 3♀ May 13; 8♀ May 21; 1♀ May 26; 7♀ May 30–31; 1♀ June 24.

Aëdes tormentor D. and K.

NORTH CAROLINA[1]—Camp Davis: (L) 1, May 26. Camp Mackall: (L) 1, June 24.

Anopheles atropos D. and K.

GEORGIA[1]—Camp Stewart: (T) 1♀ May 31.

Anopheles crucians bradleyi King

NORTH CAROLINA[1]—Camp Davis: (T) 1♀ May 7; 6♀ May 16–22; 1♂, 13♀ May 23–29; 2♀ May 31, June 4; 20♀ June 6–12; 1♀ July 9; 1♀ July 19; 3♀ Oct. 8; 4♀ Oct. 15. 2♀ Oct. 25 (S) 2♀ May 26–28; 1♀ Oct. 5; 1♀ Oct. 12.

Anopheles crucians georgianus King

FLORIDA—Camp Gordon Johnston: (L) 3, March 5; 1, April 8; 5, April 23; 2, May 17. Gainesville Airport: (L) 6, June 15; 2, June 28. Keystone Heights Airport: (L) 14, July 10.

MISSISSIPPI—Laurel Army Air Base: (L) 1, June 6.

NORTH CAROLINA—Laurinburg-Maxton Army Air Base: (L) 1, May 26; 12, June 9–12; 2, July 15; 2, Sept. 6. Seymour Johnson Field: (L) 6, April 28. Camp Mackall: (L) 3, Aug. 19; 6, Sept. 13.

ALABAMA—Napier Field: (L) 1, April 23. Tuskegee Army Air Field: (L) 2, June 23; 3, July 13; 1, July 19; 1, July 29.

SOUTH CAROLINA—Shaw Field: (L) 2, July 23. Walterboro Army Air Field: (L) 1, April 22.

Anopheles walkeri Theob.

NORTH CAROLINA[1]—Camp Sutton: (T) 1♀ Aug. 9.

Culex apicalis Adams

MISSISSIPPI—Greenwood Army Air Field: (S) 1♀ Aug. 31; 4♀ Sept. 28, 30. (L) 2, Sept. 27. Como: (B)[3] 1♀ Aug. 25; 1♀ Sept. 13. (T) 1♀ Aug. 17; 1♀ Aug. 26; 1♀ Aug. 31; 3♀ Sept. 13, 17; 2, 5♀ Sept. 20–24; 1♂, 4♀ Oct. 4–8. (L) 7, Oct. 5; 1, Sept. 27. (S) 1♀ Sept. 27. Gulfport Field: (S) 1♀ July 19; 2♀ Aug. 17; 1♂, 1♀ Aug. 22–28; 4♀ Sept. 11; 2♀ Sept. 29; 1♀ Oct. 13. (T) 1♂, 1♀ July 5–9; 3♂, 2♀ Aug. 16–20; 4♀ Sept. 20, 24; 2♂, 10♀ Sept. 27–Oct. 1; 2♂, 2♀ Oct. 4–8; 1♂, 2♀ Oct. 11, 15. (L) 19, July 17; 33, Aug. 22, 31; 3, Sept. 30; 1, Oct. 9; 25, Oct. 11–15. Key Field: (T) 1♀ Oct. 15. Keesler Field: (T) 1♂[2], 1♀ Aug. 18, 19; 4♀ Sept. 5–11; 6♀ Sept. 22–24. (S) 1♀ July 19; 3♀ Aug. 18. (L) 2, July 13; 8, July 15; 1, Aug. 24; 25, Aug. 30.

[1] Previously unrecorded from the state.
[2] Identified by genitalia.
[3] It is quite likely that these biting records are in error since *C. apicalis* is said to feed only upon cold-blooded animals.

Laurel Army Air Base: (T) 1 ♀ Oct. 5. (L) 6, May 31–June 6; 16, June 7–13; 4, June 14–20; 8, June 26; 2, Aug. 5; 9, Aug. 10; 8, Sept. 13; 3, Oct. 6; 1, Oct. 15; 2, Oct. 22. (S) 1 ♀ Oct. 6. Camp Van Dorn: (T) 4 ♂ July 5–10. (S) 1 ♀ April 6; 4 ♂, 10 ♀ May 4; 1 ♂, 1 ♀ May 18, 25; 6 ♂, 7 ♀ June 3–8; 1 ♀ June 14; 1 ♂, 3 ♀ June 21–22; 1 ♀ June 29; 4 ♀ Sept. 27; 12 ♀ Oct. 4; 1 ♀ Oct. 18. (L) 3, Feb. 3–22; 46, May 3–18; 7, June 7–21; 8, July 6–26; 4, Aug. 2; 6, Oct. 4. Clinton: (L) 2, Aug. 24; 8, Sept. 17; 44, Sept. 12; 24, Sept. 27, 28; 3, Oct. 4. (S) 3 ♀ Sept. 27, 28; 3 ♀ Oct. 4, 5; 1 ♀ Oct. 13.

Culex nigripalpus Theob.

The Tennessee records for this species are quite interesting, since they extend the range of this predominantly southern species quite far to the North. The larvae were carefully checked by the authors and other members of the laboratory staff.

MISSISSIPPI[1]—Columbus Army Flying School: (S) 1 ♀ July 13. (L) 1, Oct. 1. Keesler Field: (S) 1 ♀ May 27; 1 ♀ Sept. 22. (L) 17, Sept. 16; 2, Sept. 20, 21. (T) 3 ♀ Sept. 22, 24; 1 ♂, 18 ♀ Sept. 20, 24. Mississippi Institute of Aeronautics: (S) 1 ♀ July 2. Camp Shelby: (L) 4, Sept. 10; 30, Sept. 7, 9. Gulfport Field: (L) 3, Oct. 8; 1, Oct. 15. (T) 1 ♀ Sept. 17; 3 ♂, 15 ♀ Sept. 20–24; 2 ♂, 5 ♀ Sept. 27–Oct. 1; 20 ♂, 20 ♀ Oct. 4–8; 5 ♂, 4 ♀ Oct. 11–15. (S) 1 ♂, 1 ♀ Sept. 21; 1 ♀ Sept. 29; 1 ♀ Oct. 6. Clinton: (S) 1 ♀ Sept. 17. (L) 4, Sept. 17. (B) 1 ♀ Sept. 27.

TENNESSEE[1]—Camp Forrest: (L) 4, Aug. 9; 4, Aug. 20.

Culex pilosus (D. and K.)

MISSISSIPPI—Key Field: (L) 13, June 4–20. Gulfport Field: (T) 1 ♂ Sept. 27. (L) 10, Oct. 11, 13. Keesler Field: (T) 2 ♂[2] Oct. 11, 15.

Culex pipiens L.

Distributional records of *Culex pipiens* will be published separately.

Culex salinarius (Coq.)

This species has been collected so frequently in Mississippi and Tennessee that further distributional data from these states would be of little value.

TENNESSEE—Smyrna Army Air Field: (T) 1 ♂[2], 1 ♀ Aug. 23, 28; 2 ♂, 2 ♀ Sept. 27–Oct. 1. (S) 3 ♀ Sept. 23, 24. Dyersburg Army Air Base: (S) 7 ♂, 1 ♀ April 20, 21; 8 ♂, 9 ♀ May 12–24; 14 ♂[2], 22 ♀ June 1–26; 1 ♂, 1 ♀ June 29, July 1; 5 ♂[2], 4 ♀ July 11–15; 9 ♂, 5 ♀ July 19–29; 3 ♀ Sept. 23; 1 ♀ Oct. 6. (T) 2 ♂, 2 ♀ June 28, July 2. (B) 1 ♀ May 20. (L) 3, May 19; 4, June 11; 8, July 24; 14, Sept. 13; 10, Sept. 23; 7, Oct. 6, 7. Kennedy General Hospital, Memphis: (T) 1 ♀ May 3; 3 ♂[2], 5 ♀ Sept. 22, 24; 4 ♂[2], 6 ♀ Sept. 27–Oct. 1; 7 ♂, 1 ♀ Oct. 4–8. Municipal Airport Base Hospital, Memphis: (T) 2 ♀ May 21, 24; 2 ♂ June 24. (S) 2 ♀ April 26; 2 ♂, 1 ♀ May 3–8; 1 ♀ May 26; 1 ♀ June 24; 1 ♀ Oct. 12. (L) 4, June 17. Headquarters Second Army, Memphis: (T) 1 ♀ Sept. 10. Nashville Army Air Center: (S) 3 ♂[2], 5 ♀ May 17, 19; 5 ♀ June 18–21. (L) 11, June 4–11; 15, July 16–Aug. 2; 5, Aug. 9; 3, Oct. 11, 13.

MISSISSIPPI—Como: (T) 1 ♀ Aug. 17; 4 ♂[2], 8 ♀ Sept. 20–24; 4 ♂[2], 4 ♀ Oct. 6, 8; 10 ♂[2], 1 ♀ Sept. 29, Oct. 1; 10 ♀ Oct. 13. (S) 1 ♂ Sept. 21; 17 ♀ Oct. 4, 6; 5 ♂[2] Sept. 27; 13 ♀ Oct. 11. (R) 1, ♀ Oct. 5. (L) 1, Sept. 27. Clinton: (B) 1 ♀ Aug. 23; 2 ♀ Sept. 17; 1 ♀ Sept. 23; 13 ♀ Sept. 27, 30; 13 ♀ Oct. 5. (L) 8, Sept. 3; 21, Sept. 17; 59, Sept. 27, 28; 32, Oct. 4. (S) 1 ♀ Sept. 18; 1 ♀ Sept. 21; 4 ♂, 5 ♀, Sept. 27, 28; 1 ♂[2], 3 ♀ Oct. 4. Camp Van Dorn: (S) 1 ♂, 3 ♀ April 6; 1 ♂[2], 3 ♀ May 4–18; 1 ♂ May 24; 1 ♀ June 8; 2 ♂[2], 1 ♀ July 5–9; 4 ♀ Sept. 21, 27; 2 ♂, 3 ♀ Oct. 4; 1 ♂, 1 ♀ Oct. 11. (T) 1 ♂, 1 ♀ May 12, 24; 2 ♂ July 5–10; 1 ♀ Sept. 27. (L) 2, May 25; 11, June 3–29. Mississippi Ordnance Plant, Flora: (S) 1 ♀ April 28; 5 ♀ May 3–28; 1 ♀ July 5, 8; 2 ♂, 4 ♀ Aug. 2–Sept. 2; 1 ♂[2] Sept. 28; 1 ♂ Oct. 5; 1 ♀ Oct. 11. (T) 1 ♀ May 5. (B) 1 ♀ May 27. (L) 28, May 6–18; 10, June 25; 8 July 10; 49 Sept. 22, 23; 4 Sept. 29–30; 14, Oct. 1–6. Laurel Army Air Base: (S) 1 ♀ June 17; 1 ♀ July 4. (L) 15, May 31–June 13. (T) 1 ♂ Sept. 27; 1 ♂ Oct. 6; 1 ♂, 2 ♀ Oct. 11; 1 ♀ Oct. 18. Key Field, Meridian: (T) 1 ♂, 1 ♀ July 7, 14. (L) 4, May 21; 2, June 2. (S) 1 ♂ Oct. 10. Gulfport Field: (S) 1 ♂ May 26; 2 ♂, 23 ♀ June 1–21; 9 ♂, 24 ♀ July 5–19; 7 ♀ Aug. 5–28; 2 ♂ Sept. 11; 1 ♂ Sept. 21; 1 ♀ Sept. 29; 1 ♂, 6 ♀ Oct. 4; 2 ♀ Oct. 13. (T) 18 ♂, 23 ♀ June 14–18; 43 ♂[2], 16 ♀ June 7–25; 22 ♂, 8 ♀ June 28–July 1; 91 ♂, 147 ♀ July 5–25; 77 ♂, 43 ♀ Aug. 2–27; 1 ♀ Sept. 10; 1 ♂, 27 ♀ Sept. 20–24; 14 ♂, 36 ♀ Sept. 27–Oct. 1; 21 ♂, 54 ♀ Oct. 4–8; 2 ♂, 9 ♀ Oct. 11–15. (L) 31, May 28; 4, June 24; 10, July 1, 8; 1, Aug. 22; 1, Oct. 9. (B) 2 ♀ June 10.

Culex tarsalis (Coq.)

The occurrence of this species this year over such a wide territory and in such numbers is quite surprising. Our collections during 1942 over this same territory and from many of the same posts produced only two larvae and two adults from Camp Tyson, Henry County, Tennessee.

TENNESSEE—Smyrna Army Air Field: (T) 1 ♀ Aug. 24; 6 ♀ Sept. 20–24; 1 ♂, 1 ♀ Sept. 29, Oct. 1. (S) 1 ♀ Sept. 23. Municipal Airport Base Hospital, Memphis: (T) 1 ♀ Sept. 24. (S) 1 ♀ Oct. 7. Dyersburg Army Air Base: (S) 1 ♀ Sept. 16. Headquarters Second Army, Memphis: (T) 1 ♀ Sept. 13. Nashville Army Air Center: (S) 1 ♂ Oct. 4.

ALABAMA[1]—Fort McClellan: (T) 1 ♀ Sept. 7. Camp Sibert: (T) 5 ♀ Sept. 20–24.

GEORGIA[1]—Camp Wheeler: (T) 1 ♀ Sept. 20; 1 ♀ Sept. 24.

FLORIDA[1]—Marianna Army Air Base: (T) 1 ♀ Sept. 27.

MISSISSIPPI[1]—Mississippi Ordnance Plant, Flora: (S) 1 ♀ Sept. 13; 1 ♀ Sept. 20. Camp Van Dorn: (T) 1 ♀ Sept. 27. Greenwood Army Air Field: (T) 1 ♀ Sept. 13; 1 ♀ Sept. 20. Gulfport Field: (T) 3 ♀ Sept. 20, 24. Como: (T) 16 ♀ Sept. 13–17; 5 ♀ Sept. 20, 24; 1 ♂, 1 ♀ Oct. 6. (S) 1 ♀ Sept. 27. Camp McCain: (T) 1 ♀ Sept. 13; 1 ♀ Sept. 27. Clinton: (S) 1 ♀ Sept. 21. Camp Shelby: (T) 1 ♀ Sept. 24; 2 ♀ Sept. 27; 1 ♀ Oct. 7. (L) 1, Oct. 9. Greenville Army Air Field: (S) 1 ♀ Oct. 16. Keesler Field: (T) 1 ♀ Sept. 24. Laurel Army Air Base: (S) 1 ♀ Oct. 22.

Culiseta inornata (Will.)

TENNESSEE—Dyersburg Army Air Base: (L) 23, April 21; 19, April 27; 2, Oct. 6. (S) 3 ♀ March 23–24. Nashville Army Air Center: (S) 1 ♂[2], 2 ♀ May 17. Headquarters Second Army, Memphis: (S) 9 ♀ April 24, 30. (T) 4 ♀ April 21, 23. (L) 31, March 24.

GEORGIA—Moody Field: (L) 2, Feb. 20; 2, March 11. Camp Wheeler: (T) 1 ♂ March 19; 1 ♂ April 5; 1 ♂, 1 ♀ April 16.

Culiseta melanura (Coq.)

TENNESSEE[1]—Municipal Airport Base Hospital, Memphis: (T) 1 ♀ June 8; 1 ♂, 1 ♀ Sept. 8.

Smyrna Army Air Force Primary School: (S) 1 ♀ July 29. Dyersburg Army Air Base: (S) 1 ♂ Oct. 6.

MISSISSIPPI—Gulfport Field: (S) 1 ♂, 1 ♀ Aug. 5. (T) 2 ♀ Oct. 15. Mississippi Ordnance Plant, Flora: (S) 1 ♀ Sept. 13. Clinton: (S) 1 ♀ Oct. 4. Keesler Field: (S) 1 ♀ June 8; 1 ♀ June 30; 2 ♂, 7 ♀ Aug. 18. Key Field: (S) 1 ♀ Aug. 7. Camp Van Dorn: (S) 1 ♀ June 22; 1 ♀ Aug. 2.

Mansonia perturbans (Walk.)

MISSISSIPPI—Columbus Army Flying School: (B) 1 ♀ June 13; 2 ♀ July 21, 22. Gulfport Field: (T) 1 ♀ July 7. (B) 2 ♀ May 15, 19. Mississippi Institute of Aeronautics: (T) 1 ♀ June 9. Camp Van Dorn: (T) 1 ♀ May 12. (S) 2 ♀ May 11; 1 ♀ May 25; 1 ♀ June 2; 1 ♂, 1 ♀ June 8; 1 ♀ June 16; 1 ♀ Aug. 2.

Mansonia titillans (Walk.)

This tropical species has previously been recorded in the United States only from central and southern Florida and has been found breeding only on water lettuce (*Pistia stratiodes*). This new record is therefore quite interesting.

ALABAMA[1]—Grand View Park: (S) 1 ♀ Sept. 9.

Orthopodomyia alba Baker

An overlooked 1942 record from Maxwell Field is included here, because of the rarity of this species. The larva from Camp Shelby was sent to Doctor Alan Stone of the United States National Museum, who compared it with type material.

ALABAMA—Maxwell Field: (S) 1 ♀ May 27, 1942.

MISSISSIPPI[1]—Camp Shelby: (L) 1, Aug. 10.

NORTH CAROLINA[1]—Ft. Bragg: (L) 1, Oct. 29.

Psorophora cyanescens (Coq.)

GEORGIA—Spence Field: (L) 1, May 13. Turner Field: (S) 1 ♀ Aug. 27. Fort Benning: (S) 3 ♀ July 10–26; 1 ♀ Sept. 30. (T) 2 ♀ July 9, 26. (L) 1, June 3. Cochran Field: (B) 1 ♀ June 3; 1 ♀ July 23; 8 ♀ Aug. 2–23. (S) 1 ♀ June 2; 3 ♀ Aug. 4. (T) 6 ♀ Aug. 11–27. Fort Oglethorpe: (S) 3 ♀ Aug. 6.

TENNESSEE[1]—Smyrna Army Air Field: (T) 19 ♂, 29 ♀ Aug. 22–28; 13 ♂, 4 ♀ Sept. 13–17; 1 ♀ Sept. 22; 2 ♀ Sept. 29. (S) 1 ♀ Aug. 28; 2 ♀ Sept. 15. Camp Tyson: (T) 1 ♂ July 28. (B) 2 ♀ Aug. 5. Headquarters Second Army, Memphis: (S) 1 ♂, 3 ♀ Sept. 16. Camp Forrest: (L) 2, Sept. 7. Kennedy General Hospital, Memphis: (T) 3 ♂[2] Sept. 29, Oct. 1.

SOUTH CAROLINA[1]—Fort Jackson: (T) 3 ♀ July 15. (B) 1 ♀ July 7.

Psorophora horrida (D. and K.)

As common as the adults of this species appear to be in certain localities, it is amazing that larvae are so seldom encountered. The reared specimens from Fort Benning would have been of much more value if they had been retained as larvae.

GEORGIA—Battey General Hospital, Rome: (B) 5 ♀ Aug. 17, 19; 1 ♀ Aug. 30. Fort Benning: (R) 4 ♀ July 1. (S) 4 ♀ June 22; 4 ♀ July 3–10. Fort Oglethorpe: (S) 2 ♀ Aug. 6.

ALABAMA—Maxwell Field: (T) 3 ♂ May 6, 8. (B) 5 ♀ May 7. Tuskegee Army Air Field: (S) 2 ♀ May 12; 3 ♀ May 31. (B) 8 ♀ May 27; 16 ♀ June 17; 5 ♀ July 14, 22; 3 ♀ Aug. 3.

SOUTH CAROLINA[1]—Fort Jackson: (B) 3 ♀ July 19, 30. Shaw Field: (B) 1 ♀ July 19. Myrtle Beach Bombing Range: (T) 1 ♂ Aug. 16.

NORTH CAROLINA—Laurinburg-Maxton Army Air Base: (S) 4 ♀ July 19–27. Camp Mackall: (B) 1 ♀ July 27; 1 ♀ Aug. 24. (S) 1 ♀ July 30. Seymour Johnson Field: (S) 5 ♀ July 12, 30. (B) 3 ♀ July 7.

Psorophora howardii (Coq.)

ALABAMA[1]—Brookley Field: (B) 1 ♀ June 22. (L) 1, Sept. 23. Fort McClellan: (L) 4, May 31. Opelika: (L) 2, Sept. 24.

Psorophora varipes (Coq.)

SOUTH CAROLINA[1]—Fort Jackson: (B) 1 ♀ July 19. 58th FTD, AAFCFS (Primary), Orangeburg: (S) 1 ♀ July 30.

NORTH CAROLINA—Laurinburg-Maxton Army Air Base: (S) 3 ♀ July 19, 24; 1 ♀ July 27. Seymour Johnson Field: (S) 10 ♀ July 23; 5 ♀ July 30; 2 ♀ Aug. 7. (B) 2 ♀ July 7.

Uranotaenia lowii (Theob.)

Larval specimens must be mature or else they will be indistinguishable from *U. sapphirina*.

ALABAMA—Camp Sibert: (T) 1 ♀ Aug. 30.

GEORGIA—Cochran Field, Macon: (T) 1 ♀ Sept. 3; 3 ♀ Sept. 8, 10; 1 ♂ Sept. 15. Thomasville Army Air Base: (T) 1 ♀ July 7.

MISSISSIPPI—Gulfport Field: (S) 1 ♀ Aug. 15. (T) 6 ♀ June 7–28; 1 ♂, 104 ♀ July 5–25; 401 ♀ Aug. 2–27; 5 ♀ Sept. 10; 1 ♂, 72 ♀ Sept. 13–17; 53 ♀ Sept. 20–24; 29 ♀ Sept. 27–Oct. 2; 11 ♀ Oct. 4; 3 ♀ Oct. 13, 15. Keesler Field: (T) 35 ♀ Aug. 18–27; 322 ♀ Aug. 29–Sept. 4; 468 ♀ Sept. 5–11; 13 ♀ Sept. 14–17; 74 ♀ Sept. 20–24; 2 ♀ Oct. 11. Camp Van Dorn: (T) 2 ♀ Aug. 23, 30; 1 ♀ Sept. 20. Laurel Army Air Base: (T) 1 ♀ Sept. 20. Clinton: (L) 1, Sept. 27.

NORTH CAROLINA[1]—Camp Mackall: (L) 1, June 25.

Uranotaenia sapphirina (O. S.)

NORTH CAROLINA—Laurinburg-Maxton Army Air Base: (T) 1 ♀ June 7; 1 ♀ July 2; 1 ♀ Aug. 2; 1 ♀ Sept. 6. Camp Mackall: (T) 1 ♂, 4 ♀ May 10–June 4; 1 ♂, 7 ♀ June 7–30; 1 ♀ July 14; 2 ♀ Aug. 9; 2 ♀ Sept. 21, 22. (L) 3, July 5; 2, Aug. 9; 4, Oct. 13. Camp Butner: (T) 2 ♀ June 2, 4; 2 ♀ Sept. 18. (S) 2 ♀ Sept. 27; 1 ♀ Oct. 4. Seymour Johnson Field, Goldsboro: (T) 1 ♀ Aug. 18. Moore General Hospital, Swannanoa: (L) 1, Sept. 30. Camp Davis: (T) 1 ♂, 1 ♀ Oct. 6, 8. (L) 1, Oct. 5.—11-17-43.

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The Locust Plague

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The object of the present communication is to give a brief account of the locust problem and to show how recent advances in its study have made it possible to envisage its lasting solution.

The locust problem has confronted man since the earliest beginnings of agriculture. Biblical references to locust plagues are well-known, and Joel's description of a locust invasion has never been surpassed for its dramatic picturesqueness combined with amazing accuracy of detail. The earliest known record of locusts is a picture of a locust on the wall of an Egyptian tomb of the XIIth Dynasty, about 2400 B.C. References to locusts abound in ancient Egyptian, Hebrew, Greek and Chinese texts, and Roman writers, as Titus Livy and Pliny have left us many data, some fantastic, but some of definite value. A critical examination of this information is still awaited, and it may shed new light on certain sides of the problem.

The more recent literature on the locus problem is enormous, and the number of books and papers on the subject was estimated 15 years ago at about 2000; since then this figures has been almost doubled, owing to intensive new research. The more important contributions are published in about a dozen languages, and the task of coping with this flood is not an easy one.

It is often thought that locust plagues are restricted to a few countries and that the world at large need not be concerned about them. This view is largely due to the fact that central and north-western Europe is now practically safe from locusts, though its southern countries, *e.g.*, Portugal, Spain, Italy, the Balkan Peninsula, the Ukraine and the Caucasus, know their depredations only too well.

The zone where agriculture has to reckon with locusts and their lesser relatives, grasshoppers, becomes even wider in temperate Asia, where a broad belt of the fertile Siberian lands produces not only grain in abundance, but also grasshoppers, which take their toll of the harvest. South of that belt, Soviet Middle Asia, producing cotton, fruit, etc., is subject to ravages of the Asiatic Migratory and the Moroccan locusts. Farther east, in China, the Oriental Migratory locust has repeatedly caused wholesale famines, and is actually causing untold misery at present. The range of this locust extends to the Philippine Islands, where records of its ravages are found in the earliest Spanish chronicles, and to Borneo, Celebes, Indo-China and the Malayan peninsula.

Returning westward again, we meet the vast zone where the Desert locust holds its sway over agriculture, which is here carried out always under precarious conditions, making its products particularly precious to the population, so that a loss of harvest amounts to a major catastrophe. It is this Desert locust which has been known to man since Biblical times, and which is still as active as it was thousands of years ago. The area of its depredations is enormous, stretching from India in the east to the Atlantic coast of Africa in the west, and from Russian Middle Asia in the north to below the Equator in Eastern Africa. The tropical parts of Africa also have to cope with two other kinds of locust, the African Migratory and the Red locust. The latter extends its ravages to South Africa, which, in addition, has a very serious problem in the endemic Brown locust.

Australia, the continent where agricultural development started relatively recently, but where it has made great strides, is already paying a heavy tax to locusts and grasshoppers.

Turning to the Western Hemisphere, both the United States and Canada have to wage an almost incessant war against grasshoppers, while wide regions in Central and South America are periodically devastated by swarms of the American locust.

Thus, none of the five continents is free from these pests, which, in fact, are absent only from the forest and the tundra belts in the north, from the equatorial forests, and from the high mountains. The regions, either permanently infested by them, or subject to their periodical incursions include no less than 77 separate countries.

Beginning with the Egyptian locust plague, described in the Bible, there runs

through history a tragic tale of devastations caused by locusts, followed by famines decimating populations of whole countries. Thus, in the Roman colonies of Cyrenaica and Numidia no less than 300,000 people died in the year 125 B.C. after a locust invasion. Great famines have been caused by locusts in India, China and other countries. As recently as 1930, losses of crops valued at nearly one million pounds were caused by locusts in Morocco. In Nigeria, in the same year, a thousand tons of grain had to be imported to prevent famine; in Tanganyika Territory 25 to 100 per cent of native crops were destroyed in 1929, and in Kenya in the same year 200,000 pounds had to be spent on relief from the famine caused by locusts and drought.

These are impressive figures, but it may be argued that locust invasions occur only periodically, and that a distorted picture of their economic importance is obtained by considering exceptional cases.

To assess the cost of locusts and grasshoppers to the world, the Anti-Locust Research Center attempted to collect statistical data for a 10-year period, 1925–1934, which covered both bad locust years and years free of the insects. Statistics of this kind were not easy to obtain and only 49 countries (out of 77 suffering from locusts) submitted them. Nevertheless, the total was staggering, showing that crops to the value of 83,120,800 pounds went to feed the locusts in ten years. The losses would certainly have been greater if no defensive measures had been taken, but the latter cost another 13 million pounds. On the basis of these figures, it was not an exaggeration to estimate the average cost of locusts and grasshoppers to the world at 15 million pounds per annum. To this must be added the enormous amount of unpaid labor which is used almost everywhere for large-scale defensive measures. The data on this point are very incomplete, but the number of man-days often runs into millions in one year and in one country.

It has been argued that locusts and grasshoppers represent a danger only in backward countries, and that the advance of agriculture should inevitably lead to their disappearance as pests. A long interval during which the United States of America was almost free from grasshoppers, led some of the most eminent American entomologists to believe that agricultural progress had made a repetition of the grasshopper plagues impossible. These hopes have been rudely shattered in recent years, when grasshopper outbreaks reoccurred on a truly American scale.

Moreover, there are definite cases on record where direct encouragement was given to locusts by otherwise excellent developments. The Danube delta, for example, had become unsuitable for locust breeding on a large scale towards the end of the last century, but recent regulation of the river channel resulted in the emergence of new areas of land which were quickly utilized by locusts, and an area which had not produced locust swarms for many years became again a source of danger. In northern Borneo, locusts can breed only in areas where the jungle has been cleared for cultivation and abandoned after a few seasons; such shifting cultivation there, and probably in other similar areas, is a direct cause of locust outbreaks. In Western Australia, the clearing of dry forests in the interests of sheep-breeding has created a type of grassland admirably suited for locusts. Over-grazing of natural pastures is largely the cause of the great, and growing, grasshopper menace in Argentina, some parts of the United States and of Canada and Russia. Such facts led the Fourth International Locust Conference, held in 1936 at Cairo, to pass a resolution pointing out that the mass development of locusts and grasshoppers is furthered rather than hindered by man's activities, and that no hopes can be entertained of the problem becoming less acute merely as a result of the general development of a country.

To this must be added the consideration that the agricultural development of new areas, *e.g.*, in Africa, Central Aisa, etc., tends to increase the danger from locusts in direct proportion to the increase in the value of crops exposed to their ravages.

It may well be asked whether it might not be possible to find some use for the mass of organic matter represented in locust swarms, some of which have been estimated to amount to hundreds of tons. Chemical analyses show that locusts contain protein, fats and mineral salts which would be of value in the preparation of fertilizers and of food for cattle and poultry. From the technical point of view the idea

is sound, but no industry can be based on a raw material which may be over-abundant one year and non-existent the next.

The use of locusts for food is well known, since John the Baptist lived on them, as Bedouins in Arabia still continue to do when other food is scarce. The Assyrians apparently considered locusts as food fit for kings, since a bas relief of the seventh century B.C. shows locusts being brought up to the table of Assurbanipal. Locusts are still eaten in many countries, and the Philippine Department of Agriculture has recently published a pamphlet describing 33 different ways of cooking them. Some of the recipes sound rather attractive in war-time, perhaps, because they include such ingredients as eggs, bananas, lemons and pineapples. More plainly cooked locusts were recently described by an entomologist as "neither repulsive nor producing any pleasant sensation."

We have been speaking of locusts as a plague of agriculture, but in order to understand the problem, it is necessary to have a clear idea of what locusts are and how they live. A locust is nothing but a species of grasshopper, but often large in size and characterized mainly by gregarious habits.

The life-cycle of locusts and grasshoppers is fairly simple. The eggs are deposited by the female in the soil, in packets, or "egg-pods," each containing 30 to 100 eggs. In countries with cold winters, eggs lie dormant throughout this season, and in spring the young locusts, or "hoppers" emerge from them on to the surface of the soil. In the tropics, the eggs may hatch in 2 to 3 weeks, if there is rain or moisture in the soil. The difference between grasshoppers and locusts becomes apparent in the hopper stage; the former may be numerous, but each one lives independently of the others, whereas the latter congregate in dense groups, or bands.

Further development consists of rapid growth, stimulated by voracious feeding on green vegetation, and of the periodic moulting which occurs 4 to 6 times before the adult insect appears; the adults differ from the hoppers only in size and the presence of two pairs of wings. The whole cycle occupies a year in temperate climates, but in the tropics there may be several generations within a year.

The most striking feature in the behavior of locust hoppers is their mass movement on foot in bands which may cover several square miles. The relentless march of hopper bands which are not stopped by obstacles, even by water, creates an impression of a dark purpose, of a movement towards an objective, and many more or less fantastic explanations have been offered to account for it. Recent investigations have, however, definitely proved that the movement of hoppers depends very largely on temperature and occurs only on sufficiently hot days, while excessive heat again causes it to stop. The hopper migrations are not caused by hunger or the urge to find food, since hoppers, driven by heat, often leave a fertile area and march into open desert.

When hoppers become adult and acquire wings, they soon begin to fly about in swarms. Again, a swarm does not leave an area because of lack of food, and it does not necessarily fly towards more fertile lands, but its flight is initiated, directed and interrupted by various weather factors. Swarms may reach great size and contain fantastic numbers of individuals. Thus, a swarm in East Africa measuring 3 by 60 miles was estimated to consist of a million million locusts; and even larger swarms are on record.

The distances covered by swarm flights may be enormous. In 1693, swarms of the Migratory locust from the Danube Delta reached Wales, a distance of about 1600 miles in a straight line, though probably not in a single flight. A swarm of the Desert locust was encountered in the Atlantic Ocean midway between South America and Africa, about 1500 miles from the latter, whence it certainly came. This must have been a single sustained flight. As will be seen later, the extent of migrations becomes even greater when the swarms of several successive generations are considered.

It would be impossible even to enumerate here the many methods used, or recommended, for locust destruction. It is of interest, however, to point out that some of them are centuries old and are still in use. The destruction of eggs by digging was practised in ancient China and is still widely recommended, though it is effective only in some special cases. Beating of hoppers by branches and driving them into trenches were the methods enforced by the Romans in North Africa, according

to Pliny, and are still practised in spite of being of little value and involving the use of forced labor in astronomical quantities.

In more recent times, endless new methods have been proposed and tried against locusts, such as the use of flame-throwers, poison gases, bacterial diseases, steam-rollers, balloon barrages, smoke-screens, and even artillery. Lately, the method of poison baits has come into almost universal use. Bran, moistened with sodium arsenite solution, is scattered thinly on the ground and proves to be more attractive to locusts than green food. When the low dosage of poison, sufficient to kill locusts but not grazing animals, is strictly adhered to, there is no danger from baits, but it would obviously be an advantage to eliminate all risks. This may eventually be achieved by investigations now in progress, with dusts, which would kill locusts by contact and which could be distributed by aircraft.

However, even some of the relatively primitive methods may be of use for destroying locusts. Indeed, it is definitely not the lack of the proper technique which hampers the solution of the problem.

The main stumbling-block in the way of a solution of the locust problem is the fact that locust depredations do not recur annually but in cycles of several years, separated by clear intervals. When a country is invaded, no effort is spared to organize defense, which is rarely effective, since the organization usually lags behind the invasion. As soon as the immediate danger is over, the anxiety often gives way to wholly unjustified hopes that, perhaps the invasion will not recur, or at least, not in our time, and nothing is done until the next catastrophe, which again occurs unexpectedly. It is this unfounded optimism that should be considered as the first cause of the continual recurrence of locust plagues over the centuries.

The second reason for the failure to control locusts is the isolationist policy of practically every country subject to their depredations. History provides examples of great efforts to control locusts in Algeria, South Africa, Argentine, etc., but the results were always temporary and never led to a radical solution of the locust problem, simply because it is insoluble within a single country. We have seen that swarms in their flights may, and do, cover great distances, and that they completely lack respect for any man-made boundaries. Swarms of the Desert locust, bred in India, usually migrate to Persia and Arabia, and their progeny proceed to Egypt, Palestine and East Africa. It is clear that control measures in any one of these countries, however effective, may only protect the standing crops of the particular season, but will have no effect on the general situation.

Sporadic attempts to approach some measure of international cooperation have not been lacking. Conventions pledging each country to control locusts within its own confines have been concluded between groups of adjoining countries (*e.g.*, South American Republics; Iraq, Syria and Turkey; Persia and the Soviet Union, etc.), but all of them remained paper agreements only and had no practical effect, because they all aimed at defense only, and no attempt was ever made to take concerted measures towards a lasting solution of the problem.

The most spectacular failure of such attempts to solve the locust problem by resolutions was the Rome International Conference of 1920. A convention pledging countries represented to take all the necessary measures against locusts was signed by delegates of 18 countries, widely scattered over the globe. It appeared incomprehensible why Madagascar should join forces with Mexico, or Bulgaria with Uruguay, since they are threatened by entirely different species of locusts, and the course of events in one of them could not possibly have any effect on the other, and the solution of the locust problem remained unattainable as long as it was approached without sufficient scientific basis, though it was certainly right to regard the problem as an international one.

The irregular periodicity of locust invasions hampered scientific research on the problem, just as it did the organization of locust control. It was naturally difficult to persuade governments to spend money on locust research in the periods when swarms were absent, and little could be accomplished during the locust years, when all efforts were concentrated on defense. As a result, there was no answer to the question: "What happens to locusts when there are no swarms?" Since locusts matter only when they are in swarms, it appeared idle curiosity to ask the question, but fortunately, scientists are often

attracted by "useless" problems. In this case, entomologists in Russia and in South Africa undertook investigations, and almost simultaneously, and quite independently, arrived at wholly unexpected, but closely similar, conclusions. It was found that locusts in the years when they are not numerous differ from the swarm locusts in appearance and in habits. The external differences between the swarming and the solitary *phases* of locusts, as they came to be known, are sometimes so pronounced that the two phases were considered by specialists as belonging to different species. As regards habits, locusts of the solitary phase are typical grasshoppers, showing no inclination to form dense bands and swarms. Should, however, the numbers of locusts in a restricted area increase, so that crowding results, the locusts acquire strong gregarious tendencies. The phenomenon of phase variation in locusts has since been subjected to intensive studies, and many interesting details have been discovered, but the point of outstanding practical importance was that it opened up a possible approach to the problem of the origin of locust outbreaks.

In 1928, a serious outbreak of the Desert locust started to develop, and the British Government decided that steps should be taken to consider not only defensive measures, but also the possibility of a radical solution of the problem by ascertaining the reasons for the periodical swarming of locusts, with a view to their control. A Locust Sub-Committee of the Committee of Civil Research (later transformed into the Committee on Locust Control of the Economic Advisory Council) was formed on April 29th, 1929, and that date may be taken as the threshold of a new anti-locust policy. The actual work was entrusted to a special research unit, under the supervision of Sir Guy A. K. Marshall, then Director of the Imperial Institute of Entomology, and under the technical direction of the present writer. A scheme for collecting current information on locust movements and breeding in all countries of Africa and the Middle East was introduced, and several field investigators were sent out to study the problem on the spot. The organization, set up as a purely British one, rapidly attracted attention in other countries, and the First International Locust Conference at Rome in 1930 requested the British organization to act as the International Center for Anti-Locust Research, where all the information on the subject could ben centralized. The years 1930 to 1938 witnessed a unique concentration of scientific effort on locust investigations. Parties of British, French, and Belgian, South African, Indian and Egyptian experts systematically explored one area after another; spending months in regions which are rightly regarded as most inhospitable; establishing temporary field laboratories; and gradually disentangling the many threads of the great problem. Nor was this extensive work uncoordinated, since practically every year the experts and other representatives of the countries involved came together for a conference, to pool the results and to plan further campaigns. The accumulation of information on locusts at the International Center in the meantime went on, with a steady improvement in the unified reporting system, which by now covered the entire continent of Africa and a substantial portion of Asia. All countries in that immense region submitted monthly reports on the locust situation. These reports were critically examined, summarized and mapped, so that all developments in the situation could be followed step by step.

A feature of this international effort was its development without the signing of formal conventions and on a basis of direct collaboration between experts of many nations, with the ready support of their governments.

The results of this team-work, which is certainly unique in entomological history, have justified the effort. At the outset of the investigations, practically nothing was known on the distribution of the different species of locusts in Africa, on their seasonal cycle and migrations, and particularly, on the origin and the course of their periodical outbreaks. After eight years of intensive work, a clear picture of the whole problem became available, which has made it possible to formulate an entirely new anti-locust policy, aiming at a radical solution of the locust problem.

The investigations just outlined have provided abundant evidence that the periodicity of locust outbreaks is closely connected with the periodical transformation of the harmless solitary phase into

the dangerous gregarious one. Such a confirmation of a scientific theory may appear of no importance except to experts, but actually the theory has supplied the key to the whole problem. It was proved, that the transformation into the gregarious phase can happen, in the case of each locust species, only in certain relatively restricted areas with peculiar natural conditions, and it is only in these outbreak areas that the first swarms can be formed. In the case of the African Migratory locust it was shown that a few small swarms arising about 1928 in a restricted area on the Middle Niger in the French Sudan were the cause of an invasion which in 5 years swept over the greater part of the African continent. The outbreak areas of the Red locust have been located in Tanganyika Territory and in Northern Rhodesia. With regard to the Desert locust, it was found that its swarms can arise from the scattered locusts of the solitary phase on the coasts of the Red Sea, in Baluchistan and in Mauretania.

The fact that the great locust invasions are due to very small beginnings has important implications, for once the original outbreak areas are known, they can be put under permanent observation and any tendency on the part of the solitary locusts to form incipient swarms can be suppressed before they have had a chance to spread elsewhere. The new policy of locust control aims, therefore, at preventing the outbreaks instead of allowing them to develop into invasions and then trying to devise desperate defense measures.

This policy of prevention of locust outbreaks is clearly more rational than the old defensive policy. It is also more economical, requiring a regular annual expenditure of only a small fraction of the average annual cost of the defensive measures, apart from eliminating the losses due to invasions.

By the year 1938, the international investigations had advanced so well that it was possible to formulate practical plans for dealing with the three main locust species affecting Africa and the Middle East. At the Fifth International Locust Conference held at Brussels in 1938, definite schemes were elaborated for establishing permanent organizations for the control of the Desert, Migratory and Red locusts. These plans, naturally, required further discussions of administrative and financial details, and these extended into 1939, when the outbreak of the war made the locust problem appear insignificant.

Very soon, however, it became apparent that the war would demand a maximum production of foodstuffs and that crops must be safeguarded from locusts. Unfortunately, most of the outbreak areas of the Desert locust were near, or very close to, the war zone, and the outbreak areas of the Migratory locust became inaccessible to outside experts after the fall of France. There remained only the Red locust, and the scheme for its control, supported by the British colonies and protectorates in East Africa, by Southern Rhodesia and the Belgian Congo, was launched in 1940. Recently, it became known that an organization for preventive control of the Migratory locust has been established by French authorities without waiting for international support, which must be given as soon as possible. Thus, in spite of the war, the foundation-stone of permanent international locust control was laid.

It was a most unfortunate coincidence that, after a quiet interval of several years, the Desert locust exhibited signs of renewed swarming just as the war broke out and the first swarms had a chance to escape observation and destruction. By the time the areas in question had become more accessible, the swarms were not numerous, but sufficiently widespread to necessitate an urgent campaign for the protection of crops throughout the Middle East and East Africa. From the point of view of organization, war conditions proved to be, paradoxically, more favorable for an anti-locust campaign than normal times. The importance of safeguarding vital food supplies, both for the troops and the population, became a powerful factor in obtaining the willing cooperation of all concerned. This made it possible, for the first time in the history of locust control, to organize not a dozen small national campaigns, designed mainly for defense, but a unified campaign, embracing the whole affected area and assuming the character of offensive operations. These operations are based on a knowledge of the seasonal movements of swarms, which has been accumulated in past years and which makes it possible to forecast the course of events with con-

siderable accuracy. It is a matter of justifiable pride for the Anti-Locust Center that in the present invasion every country has received a timely warning which later proved to be correct.

The situation at present is as follows: Swarms are concentrated mainly in southern Persia, and Arabia, whence they are expected to move in the spring eastward into India, northward to the borders of Russian Middle Asia, and north-westward in the direction of Palestine, as well as into East Africa. In both Persia and Arabia the locusts should remain relatively inactive throughout the winter months, and for this reason these areas are regarded as strategically important in planning the winter campaign. An outstanding feature of this campaign is its organization by the joint efforts of several nations. Persian, British, Russian and Indian experts are sharing the work in Persia. In Arabia, British, Indian and Egyptian mobile units are operating according to a common plan. At the same time, the necessary operations are proceeding in all affected countries of Africa, where the work of local anti-locust organization is correlated with the general plan, and a British anti-locust mission is at work in Ethiopia. An anti-locust campaign of such unprecedented magnitude, which has to be conducted partly in areas recently considered quite inaccessible, presents great difficulties, and too optimistic an estimate of its outcome may be premature, but even if the outbreak is too far developed to be completely suppressed, it can be confidently hoped that its effects will be substantially reduced.

Passing from the past and the present to the future of locust control, is well to remember that freedom from want should be one of the cornerstones of a better world. The builders of that world will have to plan on a scale which makes problems such as the present one look insignificant, but the greatest plan may fail if small details are overlooked. The locust problem is one of these minor details, which must not be forgotten when the economic development, particularly of the tropical and sub-tropical regions, is considered. No plans for increasing the productivity of a region can be regarded as complete unless they ensure that none of the new abundance will be wasted on feeding locusts. If such waste has been going on for centuries past, it was due partly to insufficient knowledge, and partly to the lack of international cooperation. Neither of these excuses holds any longer. The recent advances in anti-locust research have supplied a sound scientific basis for solving the problem, and the work in Africa and the Middle East has shown that effective international cooperation can be attained if the countries concerned are offered a definite scheme aiming at practical results.

DR. GEO. C. DECKER SUCCEEDS PROFESSOR FLINT

It has just been announced that Dr. George C. Decker has been appointed to succeed Professor W. P. Flint as Entomologist of the Illinois Agricultural Experiment Station and Entomologist of the State Natural History Survey.

Dr. Decker has been for some years on the entomological staff of the Iowa State College and the Iowa Agricultural Experiment Station and Extension Division and previous to that time had been Entomologist with the Georgia State Board of Entomology. Dr. Decker plans to assume his new duties on March 1.

Insects Associated with the Palay Rubber Vine in Haiti[1]

PAUL KNIGHT, *San José, Costa Rica*

The Palay rubber plant, *Cryptostegia grandiflora*, is being planted on a large scale in the Republic of Haiti in connection with the emergency rubber program of several cooperating agencies of the United States government. Since 100,000 acres are scheduled to be planted before the close of 1943, in very extensive tracts, some knowledge of the pests of this unusual vine may be needed as the plantations mature. There is evidence that some insects attacking the plant may develop to epidemic proportions as the acreage increases.

During the period of investigation of the insect pests of *Cryptostegia* by this writer, from February 10 to April 14, 1943, the winter dry season prevailed until April 3. During this dry period virtually no rain fell and irrigation was practised continually. At the time the survey was terminated little notion of the difference between wet and dry periods was available except to notice a few profound changes mentioned later in this paper. All survey work was made in the semi-desert area near Gonaïves, Haiti, where both wild and cultivated stands of mature *Cryptostegia* were available. It was in this area that one of the earliest if not the first introduction of the species was made on the island of Hispaniola.

Cryptostegia grandiflora is a member of the milkweed family (Asclepidiaceae) though most of the insect pests of the typical and common genus *Asclepias* show no affinity for it. This proved true of both phytophagous and pollenizing species.

The most significant pest of *Cryptostegia* during the period of investigation was the cotton aphid, *Aphis gossypii* Glov. Seedling plants were attacked as soon as they developed their first leaves and damage continued through all stages of growth to full maturity. Injury was greatest to young plants and to the vigorous new growth of older plants. There was a prevalent belief on the part of some agriculturists in Haiti that the wet season would bring about a marked dimunition in the aphid population. The reverse proved to be true. To cite a single example, one week after the first significant precipitation the aphid infestation on blossom buds increased from 34 to 89 per cent of the total number of blossoms infested. This condition held true generally in the case of growing shoots of older plants. There was not a corresponding increase in the number of infested seedlings because these small plants were standing so close in seed beds that the infestation was always near 100 per cent but populations increased considerably. Throughout the Gonaïves Desert the cotton aphid was abundant on *Cryptostegia* but the percentage of infested shoots was much less at all times in wild stands than in the plantation fields. Even where cotton and *Cryptostegia* grew side by side, in some cases touching, the latter was much more heavily infested.

There may be some significance in the fact that at no time were parasitized aphids found on the rubber plant though the cotton aphid was parasitized on cotton by the widely distributed *Lysephlebus testaceipes* (Cress.). This parasite was also reared from *Aphis maidis* Fitch on corn, millet and several undetermined species of succulent grasses, and had destroyed 100 per cent of an undetermined aphid on a gigantic, tree-like species of *Asclepias* common to the Gonaïves Desert. The apparent freedom from parasitism may be due to certain properties of the latex of the *Cryptostegia* vine. (Chemists have shown the latex to be acid rather than alkaline as in the case of the Para rubber tree, *Hevea braziliensis*.) Parasitism may exist elsewhere or at other seasons on the same host and this calls for a more thorough check. This observation is cited in the hope that other observers may make a thorough check in Haiti and elsewhere. It appears well established that in some cases the extent of parasitism of an insect can be influenced by the host plant.

Various insects predatory upon the cotton aphid were collected. Four species of Coccinellidae, listed in the order of their abundance, were *Cycloneda sanguinea* var. *limbifer* Casey, *Scymnus* sp., *Coleomegilla cubensis* Casey, and *Hyperaspis*

[1] This paper is a brief summary of a more extensive report submitted to the Research Division of the Cryptostegia Project of the Société Haitiano-Américaine de Development Agricole, Port-au-Prince, Haiti. Control investigations were the work of another investigator.

connectens (Thunb.). The first two named were extremely abundant at all times. The predatory larvae and the puparia of *Leucopis simplex* Loew (Agromyzidae) were very numerous, especially in the closely packed seedling beds. The most prevalent member of the Syrphidae was *Baccha clavata* (F.), found in large numbers on plants of all ages. The widely distributed parasite, *Pachyneuron allograptae* Ashm. was found to have parasitized 74 per cent of all *Baccha* puparia collected from the rubber vines. A less common syrphid was never reared because of complete parasitism of all puparia collected by the same species of wasp. The puparia yielded from 2 to 12 parasites each with an average number of 6.6.

Second in actual importance during the same period was the hemispherical scale, *Saissetia hemispherica* Targioni, though potentially this species appears to be capable of far more serious injury to the *Cryptostegia* plantations. Whereas the cotton aphid had reached what appeared to be a near-maximum potential the scale was only beginning to disperse and a marked increase in the number of infested plants could be observed each month. In March, 1943, only a few plants were heavily infested but an alarming number were in the early stages of infestation. Nursery plants from 2 to 8 inches in height and about 10 weeks of age were infested to the extent of 3.57 per cent. From these small seedlings to vines 6 months old and ready for "tipping" or harvesting the infestation gradually increased according to the age of plants to 55.5 per cent. Distribution of the scale-infested plants was charted in three experimental plots and showed a very rapid dispersal within rows. In some plots the number of infested plants increased 20 per cent within a month. Wild *Cryptostegia* that had been growing vigorously for many years along a nearby river was slightly infested.

In both cultivated and wild plantings evidence of parasitism was negligible. After 8 weeks' observation a single specimen of *Coccophagus cubaenis* Comp. was reared from hemispherical scale. Occasional exit holes apparently made by this species were found, but the number was never large. Several species of ants were constantly associated with the scale; most common of these were the fire ant *Solenopsis geminata* (F.) and *Dorymyrmex pyramicus* var. *niger* Perg. No evidence of ants carrying scales was noticed.

The fire ant became a pest on scale-infested vines and also on plants in bloom and may seriously inconvenience the latex harvest. At present the only method that has been devised to gather latex from the palay vine is to "tip" or cut the ends of the long, mature whips of the plant and allow the latex to flow into a container such as a coconut shell, gourd or bamboo trough. This crude method, involving an enormous amount of hand labor may later be supplanted by something more economical. The vicious biting habit of the fire ant is too well known to entomologists to require any elaboration as to the effect this tiny species may have on field harvesting. In experimental plots the ants were excluded from a few rows of vines by the simple method of typing a small wad of cotton around the base of each plant but no practical way was found to treat the infestation on a large scale. In another way the fire ant and other species to a lesser degree, cause considerable injury to blossoms and may reduce considerably the production of seed. The production of seed pods became an important issue because propagation was entirely by seed, either in beds or from wild seedlings. Seed production is also important because of the large amount of latex that is produced in the pods. While the blossoms of the *Cryptostegia* look little like those of the genus *Asclepias* the mechanism of pollination is fundamentally the same. Pollination is accomplished when certain insects remove the "translator" from between the stamens and the pistil. Small ants, especially *Solenopsis*, remove these translators and carry them away but in so doing they appear to bruise severely the surrounding flower parts. Station botanists at Gonaïves were of the opinion that ants were at least one of the reasons for the low production of seed pods. Due to the failure to determine the amount of seed production under any type of circumstances the extent of ant injury cannot be accurately established. During periods when ants were not prevalent on the plants the percentage of seed production was very low, but in spite of this fact it is difficult to examine blossoms after these insects have removed several of the translators without arriving at the conclusion that their damage may

be serious. The number of ant-infested blossoms ranged from as low as 3 per cent on days following heavy rain to as high as 34 per cent after two or three days of dry weather. Their activity in the blossoms usually ceased before noon.

Chewing insects were almost non-existent on the *Cryptostegia* plant during the dry season but in early April large numbers of Curculionidae began attacking the vines and causing serious injury. The attacks of these insects coincided very closely with the first heavy rain, coming but three days later. Eight or more species of weevils appeared almost overnight, causing considerable feeding injury to leaves, buds, and tender shoots. As many as 80 individuals were removed from vines less than 18 inches in height. No attempt was made to count the numbers on large plants. Specific determination of most of these insects will be impossible until the Division of Insect Identification of the U. S. Bureau of Entomology and Plant Quarantine is able to compare the writer's specimens with the types in the British Museum as there is considerable confusion in the taxonomy of West Indian Curculionidae. There were no less than three species of *Lachnopus*, three or possibly four of *Artipus*, probably one of *Exophthalmus*, and the common *Exophthalmus quadrivittatus* Oliv. All species were present in enormous numbers.

Also coincident with the wet season was a decided increase in the number of adults of a milkweed bug, *Oncopeltus aulicus* (F.) superficially indistinguishable from the common *O. fasciatus* (Dallas) of eastern United States. The former had been present throughout the dry season on several species of *Asclepias* but had rarely been collected on *Cryptostegia*. This was the only example observed of a species common to both genera of the milkweed family.

Occasional visitors were the cicada *Proarna hilaris* (Germ.) never observed ovipositing, and two large Scoliidae, *Campsomeris tolteca* (Sauss.) and *C. trifasciata* (F.) both of which often tried unsuccessfully to enter the flower receptacle. One unidentified Megachilid and a few small bees were collected. The blossom of Cryptostegia is visited by a comparatively few species.

Cryptostegia grandiflora is entirely insect pollinated. Of the few insects known to visit the blossoms most have mouthparts too short to reach the mechanism. During the dry season it was extremely difficult to observe actual pollination, but on three occasions the skipper *Atalopedes mesogramma* (Latr.) was seen leaving the blossom with one of the small, spatulate translators adhering to the tip of its proboscis. Likewise the hesperiid *Lerodea* sp. was observed. From a superficial study of the pollination of *Cryptostegia* it is apparent that a very limited number of species are involved. Smaller insects than the two species of skippers possessed mouth-parts too short to penetrate the flower to the proper depth. Some of the larger lepidopterous species having long coiled probosces were unable to use this advantage due to the fact that the insects were too large to enter the corolla of the blossom. *Atalopedes* has a proboscis 17 millimeters in length, sufficient to reach the translators when the insect has penetrated the depth of the convolute corolla. The large peirid *Phoebus sennae sennae* (L.) was common in the plantations at all times and was observed daily trying to enter the blossoms. Due to its size this insect was unable to reach the translators in spite of the fact that its uncoiled proboscis measured 25 millimeters. In the vicinity of Port-au-Prince, where rainfall is abundant during February, March and April, many species of Hesperiidae including the two previously mentioned species were abundant on various leguminous trees and shrubs. It seems quite possible that in regions of greater rainfall than occurs at Gonaïves pollination may not be a serious problem. All attempts to pollinate the flowers by hand failed. At the close of this investigation there were no mature plantings of *Cryptostegia* elsewhere in Haiti, and in the wild, naturalized plantings the seed pods had been removed by natives who were being paid to harvest all seed available.

Cryptostegia grandiflora, like many other latex-producing plants, seems to harbor a comparatively small number of insect pests. This fauna, however, is not as limited as certain observers in Cuba, Haiti and the Dominican Republic have indicated. Enthusiastic reports as to the lack of insects were the result of observations on comparatively small groups of naturalized plants and appear to be altogether too optimistic.—10-25-43.

SCIENTIFIC NOTES

Methyl Bromide Fumigation for the Delousing of Troops

RANDALL LATTA, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine.*

The United States Army is using methyl bromide[1] in two types of equipment for the delousing of troops (1) in individual gastight fumigation bags in which one soldier's outfit is treated, and (2) in fumigation vaults in which large quantities of clothing are treated. The fumigation vaults are of two types, permanent for ports, hospitals, depots, etc., and demountable for mobile use.

The individual gastight fumigation bags were put into use early in the war, and accompanied troops to Africa and to other foreign theaters of operation. These bags are made of fabric coated with a relatively gastight plastic material. A soldier's outfit and clothing is put into the bag together with a glass ampule of methyl bromide. After the bag is properly closed, the ampule is broken, releasing the fumigant as a gas. After a 45-minute exposure period the clothing is dumped from the bag and, after shaking, may be immediately donned by the soldier.

The earliest bags were coated with ethyl cellulose, which proved to have certain drawbacks, such as stiffness in cold weather, and a tendency to fuse with itself when stored in warm places. Following the beginning of the African campaign, ethyl cellulose was restricted to use on certain other military items, and the bags were then coated with one of the better synthetic rubbers. This was an advantage rather than a detriment, since rubber coating is much more satisfactory from all standpoints.

Our Army has made wide use of this method of fumigation, and its simplicity has made it the subject of considerable publicity. The production figures, of course, are confidential, but fumigation bags have been produced by the hundreds of thousands, while the ampules run into many millions.

The fumigation vaults, as noted, are of two types, permanent and mobile. The permanent type is set up in regular delousing stations at ports of embarkation or debarkation, hospitals, depots, etc. For mobile use, demountable or knockdown are used which can be assembled in less than 10 minutes.

In both uses, the operational plan is the same. The men are brought to the stations in companies. They undress and place all their clothing and equipment in numbered barracks bags. The barracks bags are placed in the fumigation vault—50 to 75 per vault—and treated while the men proceed through showers, and medical examination, and are sprayed with a louse spray containing an ovicide. By the time they finish this procedure their clothing is ready for them again. The vaults are operated in batteries of 3 to 6, being loaded in rotation. By this method 150 to 450 men per hour can be deloused in a continuous operation.

The mobile units are called Fumigation and Bath Companies and are operated by the Quartermaster Corps. Each company has two platoons, each of which can operate independently. A platoon has three fumigation vaults and one trailer-type flash boiler which heats creek water for the showers. Tents are used for shelter for the men while undressed. These companies travel by truck, and can locate along the bank of a stream, set up their vaults and tents, and be in operation in less than one hour.

The Armed Forces have educated their men so well concerning lice and typhus that apparently very little trouble has been encountered. Reports indicate that the occurrence of lice on soldiers is not nearly so common as in the last war, and no heavy infestation has been reported.—12-17-43.

[1] The research on the use of methyl bromide for the delousing of troops was done by the Bureau of Entomology and Plant Quarantine. Acknowledgement is made of a certain amount of aid, funds for which were provided by a transfer of funds, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Bureau of Entomology and Plant Quarantine.

Anthocomus bipunctatus (Harrer), A new Household Insect

G. T. FRENCH, *Richmond, Virginia*

During March, 1943, a small soft winged beetle taken in dwellings around windows and other places was called to our attention by several Richmond people. Because of the numbers reported and because we were not familiar with the species, material was forwarded, on March 31st, to Dr. P. N. Annand, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C., for identification. Under date of April 5th, Mr. Hoyt, Acting Chief of the Bureau, replied that it had been identified as *Anthocomus bipunctatus* (Harrer), family *Malachiidae*, and that it was a European species which had only once previously been reported from the United States. In 1940 two specimens from Summit, New Jersey, also collected in a house, were submitted for identification.

Hoyt further stated that no information seemed to be available concerning the habits of *A. bipunctatus* and whether or not it may be a pest of any significance could not be determined at present.

Beetles were collected as follows during 1943:—

In March, date not recorded, April 21st, in house, mostly on screens; April 8th to 20th, in a dwelling, mostly at windows but in other places and most numerous in unfinished parts of attic; in rose flowers, April 16th; on apple blossoms, April 18th; in house, May 6th; and in gutters of house, May 29th; on May 9th, taken in automobile.

Dr. Annand, reporting on material forwarded for identification on April 20th, stated that all specimens submitted to that date had been identified by Mr. H. S. Barber, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, as *Anthocomus bipunctatus*. He further states that Mr. Barber feels that from what little is known of the *Malachiidae*, to which family this species belongs, it is a predator, the larvae probably feeding on various household insects such as silver fish.

The indications are that *Anthocomus bipunctatus* may be a nuisance pest in disguise. A nuisance because of its appearance in houses in large numbers, but a beneficial insect because it is predacious on several destructive household insect pests.

DESCRIPTION OF ADULT BEETLE.—*Anthocomus bipunctatus* (Harrer): Head and thorax black; abdomen extending beyond elytra. Upper abdomen orange, under parts black, segments marked by orange lines. Elytra orange red with black spot on each elytron, coalescing on inner edges about one-third of distance from tip. Length 3–4 mm.

Particle Size of Commercial Calcium Arsenates by Air-Permeation Tests[1]

ERNEST L. GOODEN, U.S.D.A., *Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Particle size of calcium arsenates was studied by Goodhue (1937) in a recent survey. The means of measurement was sedimentation. Since that time air permeation has come to the fore as a means of evaluating powder fineness, and a self-calculating air-permeation apparatus is now used in most tests of particle size in the Bureau of Entomology and Plant Quarantine. It is therefore deemed appropriate to report here the results of observations on calcium arsenates by this method.

The samples used in this survey comprise all the calcium arsenate samples submitted to this laboratory for particle-size tests in 1941 and 1942. They were produced by various manufacturers and are believed to be collectively representative of insecticidal calcium arsenate on the American market.

The result of an air-permeation test is expressible either as specific surface (square centimeters per cubic centimeter) or as surface mean diameter. The two terms have a simple relationship, such that if a sample has a surface mean diameter of d microns it has the same specific surface as a hypothetical sample composed of spherical particles d microns in diameter. The instrument here used is calibrated to read surface mean diameter, in microns.

The apparatus is that described by Gooden & Smith (1940) and Gooden (1941b), with the compactor developed as an accessory and described in later publications (1941a, 1942). Because of the extreme fineness of calcium arsenate, certain simple changes in the amount of sample and in the flowmeter resistance were made to increase the sensitivity of the instrument and thereby facilitate the readings.

RESULTS.—In practically all the samples the mean diameter was of the order of 1 micron. Except for two abnormally coarse samples out of a total of 81, the values ranged from 0.5 to 1.4 microns. The two exceptional values were 2.2 and 2.7 microns. The cumulative distribution of mean diameters is shown in figure 1. The values for ordinary calcium arsenates are among the lowest found for common insecticidal powders.

ACCURACY.—Owing to the size range involved, a high degree of accuracy is not to be expected with any known method. With the optical microscope most of the measurements are near the limit of resolution, and even with the electron microscope there is the difficult problem of estimating the third dimension. Sedimentation is rendered inadequate by Brownian movement. Gas adsorption is adaptable to this particle-size range, but calcium arsenate, like many other materials, will not stand the rigorous pretreatment that seems to be necessary for removing adsorbed water.

The low-size limit of applicability of the air-permeation principle has not been established. In unpublished experiments by the author, air-permeation diameters of bronze and aluminum powders were found to check remarkably well with determinations by other workers using the single-particle-layer method of Edwards & Mason (1934), with samples whose range of surface mean diameters was

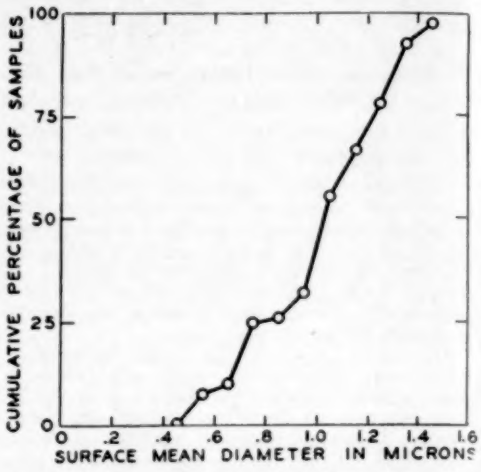

FIG. 1.—Average diameters of calcium arsenates as determined by the permeation method.

almost identical with that of the calcium arsenates. On the other hand, there is evidence that with much finer powders, such as many carbon blacks, the air-permeation method as now used will give diameter values seriously too high, owing to inequality of pore sizes in the powder column. From the experience with blacks it is implausible that the calcium arsenate values are too low, and with the evidence contained in the sedimentation report of Goodhue (1937) one would hardly believe they are much too high. No direct comparison with the sedimentation results can be made, because of the necessary incompleteness of the sedimentation analyses; a majority of the samples had the greater part (by weight) below the lower limit of the analyses, 6 microns.

In the permeation survey of calcium arsenates a representative density value, 3.10 grams per cubic centimeter, was used throughout. Although, as is shown by Goodhue, the density varies appreciably (2.95 to 3.32 grams per cubic centimeter), the increase in accuracy of diameter obtained by individual density determinations would be barely significant.

PARTICLE SIZE *vs.* WATER SOLUBILITY.—IsonNe & Cassil (1937) pointed out an apparent correlation between percentage of water-soluble arsenic by the Geneva method (Pearce *et al.* 1935) and percentage below 10 microns diameter by sedimentation, and offered a possible explanation. Since percentage below 10 microns is a very indirect measure of particle size, it was thought advisable to see if further evidence on the relation of soluble arsenic to particle size could be gathered from the present work. Data on water-soluble arsenic by the method mentioned above were available for more than 90 per cent of the samples. Statistical treatment showed a distinct trend toward association of large particle size with high soluble arsenic, but the low correlation coefficient (0.7) indicates that neither property can be predicted accurately from the other without the introduction of an equally important additional factor or group of factors.

SUMMARY.—A survey of calcium arsenates sold for insecticidal use shows that the surface mean diameters as determined by air permeation lie almost exclusively in the range 0.5 to 1.5 microns.

[1] Acknowledgment is made to H. D. Mann, of the Bureau of Entomology and Plant Quarantine, for the chemical data discussed.

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Observations on *Prospaltella perniciosi* and Its Mass Production

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Prospaltella perniciosi Tower was introduced into California from the Atlantic seaboard in March, 1943, by the University of California Agricultural Experiment Station in cooperation with the Federal Bureau of Entomology and Plant Quarantine. By the end of the year about 200,000 females of *P. perniciosi* were produced for liberation. *P. perniciosi* was recovered during July from peach trees infested with San Jose scale located at Cucamonga, California. This work was done by Glenn Finney under the direction of Professor Harry S. Smith, head of the Division of Beneficial Insect Investigations.

In 1914, H. T. Fernald (1914) reported on his observations which led to the recognition of *Prospaltella perniciosi* as a new species. He stated that "I have been watching the parasites of the San Jose scale in Massachusetts for eight years and their numbers have been discouragingly small during that time. In the fall of 1912, however, quite a large number of parasitized scales were found and suspecting that something unusual might be going on I had one of my students make collections. . . . In these collections about 80 per cent of the scales were parasitized. . . . As a result of the observations which have been made, we found that during the past fall, in some localities, 90 per cent of the scales are parasitized. . . . Our best results have been secured from collections made from unsprayed trees such as *Cornus* and *Salix*."

H. Compere informed the writer that in 1934 he observed a little of the work of *Prospaltella perniciosi* on San Jose scale in Brazil and was considerably impressed by the degree of parasitization. Compere made a trip to Municipio Susana in an effort to obtain *P. perniciosi*. There a few young plum trees were found infested. The exposed coccids were dead with parasitism clearly evident. The few live specimens were completely concealed by mats of a black, densely growing fungus, which apparently protected the scales from parasitic attack. The parasitized specimens were dry parchment-like mummies fastened to the bark, the exuviae having weathered and fallen away.

The technique of producing San Jose scale is similar to that of producing red scale (Flanders 1943). Following the example of the Orange County Insectary, the citron or cow-melon, *Citrullus vulgaris*, has been substituted for species of *Cucurbita* as a laboratory host-plant of various diaspine scale insects.

The melons used in parasite propagation should be mature and about 6 to 8 inches in diameter. The investation of a melon is obtained by brushing newly hatched "crawlers" from well-infested "mother" melons. The San Jose scale reaches maturity in about 37 days after hatching when the temperature of its environment is about 80° F.

All the post-embryonic stages of the scale are susceptible to attack by *Prospaltella perniciosi*. This parasite is so small and reproduces so readily that extra precautions must be taken to exclude it from the room devoted to the production of San Jose scale.

In the propagation of the parasite the infested melons are placed in cages similar to that illustrated in figure 6, plate 15 of Peterson's Manual (1934). The cage is stocked either with adult parasites or with an infested melon which is producing parasites. The minimum developmental period of *P. perniciosi* from egg to adult is about 19 days at 80° F. Development may be prolonged if the host is in its first stage when attacked by the parasite.

It was observed that when mass production occurred on citron the male sex disappeared from the cultures. It is probable therefore that *Prospaltella perniciosi* is uniparental in reproduction. However, when males are present mating occurs readily as noted by Tower (1914). According to Rice (1937) the male of *P. perniciosi* is an indirect hyperparasite.

Whether the female of *Prospaltella perniciosi* is thelyotokous or amphitokous may depend on the condition of the scale in which it developed.—11-12-43.

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Sprays of 2,4-Dinitro-6-Cyclohexylphenol for Control of the White Apple Leafhopper

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During the progress of studies relative to the effects of sprays for the European red mite on apple it was observed that there was a decided reduction in the leafhopper infestation on plots sprayed with DN insecticides.

In the last few years certain research workers have shown that dusts composed of DN or the dicyclohexylamine salt of DN were toxic to mites and some species of thrips. Recently DeLong & McCall (1943) have shown that combinations of DN dust and sulfur gave satisfactory control of the potato leafhopper, *Empoasca fabae* Harr., on several species of plants.

In order to determine the value of DN sprays for control of the white apple leafhopper, *Typhlocyba pomaria* McAtee, tests were made in an apple orchard infested with leafhoppers. This paper gives a summary of the experiments for control of the white apple leafhopper in 1943.

The test area consisted of one row of Winesap and two rows of York Imperial apple trees. Each row was divided into four plots and three treatments and a check appeared in each row. In each plot two count trees were selected at random. Two days after the sprays were applied twenty leaves from each count tree were examined for leafhopper nymphs and a record was made of the number of live nymphs present.

Table 1.—Summary of results of experiments for white apple leafhopper.

Materials and Amount for 100 Gallons	Sprays	Nymphs per 100 Leaves	Per Cent Reduction
DN-111, 20 ounces	2	96	87.2
D-41, 5 ounces Blood albumen, 2 ounces	2	77	89.7
Nicotine sulphate (*Black-Leaf 40*), 1 pint Grasselli spreader sticker, ½ pint	1	45	94.0
Check	0	750	—

The two DN materials[1] used were dry-mixes. *D-41* contained 40 per cent of 2,4-dinitro-6-cyclohexylphenol. *DN-111* contained 20 per cent of a dicyclohexylamine salt of 2,4-dinitro-6-cyclohexylphenol. For comparison nicotine sulphate (*Black-Leaf 40*) was used in the tests.

The sprays were applied with an orchard sprayer, using a single nozzle gun with a pump pressure of 500 pounds. All the spraying was done from the ground and the trees were thoroughly sprayed from the inside and from the outside.

The plots that were sprayed with the DN materials received two applications of spray, applied at an interval of 8 days. The plots sprayed with nicotine sulphate received one application of spray. All the sprays were applied before the leafhoppers had reached the adult stage.

Records made after the first application of spray show that the DN materials did not give satisfactory control. However, as can be seen in table 1, two applications of the DN materials greatly reduced the leafhopper population and compared quite favorably with one application of nicotine sulphate.

From one season's work it appears that sprays of DN or the dicyclohexylamine salt of DN offer a great deal of promise as a control for the white apple leafhopper.

No injury to the foliage of apple was observed where two applications of the DN insecticides were used.—11-16-43.

[1] Supplied by The Dow Chemical Company, Midland, Mich.

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Distribution of *Culex pipiens* in the Southeastern United States[1]

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The southern range of *Culex pipiens* L., the northern house mosquito, is known to extend well into that of *Culex quinquefasciatus* Say, the southern house mosquito. Dyar (1928) gives the southern limit as the thirty-eighth parallel of north latitude which is roughly northern Virginia, southern West Virginia, and northern Kentucky. King *et al.* (1942) extend the known range to North Carolina and Tennessee. Some of this confusion is undoubtedly due to the fact that these two species are quite similar morphologically in both larval and adult stages; so much so, in fact, that identification must be based upon a careful examination of the male genitalia.

It has been the practice of taxonomists to call northern specimens *pipiens* and southern ones *quinquefasciatus*. This geographical separation of species did not work out in the transitional zone, which is considered to be a belt of varying depth including the states of North Carolina, Tennessee, Virginia, Kentucky and southern West Virginia. Actually there has existed very little information on the southern range of *C. pipiens* based upon a study of male genitalia.

When the Fourth Service Command Laboratory of the U. S. Army was established at Fort McPherson, Georgia in October 1941, facilities were made available to conduct extensive mosquito surveys throughout North Carolina, South Carolina, Tennessee, Mississippi, Georgia, Alabama, and Florida at approximately 140 army installations. The taxonomic work involved was to be accomplished at this laboratory by entomologists trained in mosquito identification. In 1942, sufficient data were accumulated to extend the range of *C. pipiens* from several previously recorded points in Tennessee and North Carolina to include parts of Georgia, South Caro-

[1] The authors wish to acknowledge the services of both civilian and army personnel in the laboratory and in the field which made the compilation of these data possible. They are particularly indebted to Miss Jeanne Pryor, Miss Leanora Peeples, and Capt. W. W. Middlekauff of the Fourth Service Command Laboratory, and to Lt. James Toffaleti, Lt. Louis Roth, and Lt. Harry Hoogstraal, former members of the laboratory staff.

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[3] Sergeant, Medical Department, A.U.S.

[4] Major, Sanitary Corps, A.U.S.

Table 1.—1943 collections of male *Culex pipiens* ("A" in table) and *C. quinquefasciatus* ("B" in table) from posts in the Fourth Service Command where *C.* have *pipiens* been taken.

	JUNE	JULY		AUG.		SEPT.		OCT.		TOTAL	
	"A"	"A"	"B"	"A"	"B"	"A"	"B"	"A"	"B"	"A"	"B"
[1]Dyersburg, Tenn.	—	24	9	9	1	23	3	41	13	97	26
[1]Memphis, Tenn.	—	5	—	14	22	11	20	14	47	44	89
[1]Nashville, Tenn.	—	—	—	—	—	—	—	2	7	2	7
Paris, Tenn.	6	139	1	180	6	89	2	24	3	438	12
[1]Smyrna, Tenn.	—	7	3	5	15	2	103	—	15	14	136
Tullahoma, Tenn.	18	2	—	1	—	3	5	10	7	34	12
Durham, N. C.	38	18	1	55	—	112	—	86	14	310[2]	16[2]
[1]Goldsboro, N. C.	—	—	—	1	—	—	—	1	—	2	0
[1]Greensboro, N. C.	—	5	—	9	1	15	4	2	5	31	10
[1]Hoffman, N. C.	—	—	—	16	12	—	66	—	6	16	84
[1]Maxton, N. C.	—	—	—	1	—	—	—	1	—	2	0
Monroe, N. C.	161	63	—	92	18	207	63	21	—	544	86[4]
[1]Swannanoa, N. C.	—	—	—	23	—	34	—	8	—	65	0
[1]Wilmington, N. C.	—	—	—	—	—	1	12	4	29	5	41
[1]Greenville, S. C.	—	—	—	8	—	—	—	2	58	10	58
Spartanburg, S. C.	—	—	1	14	36	22	6	24	10	60	53
Oglethorpe, Ga.	—	2	—	—	—	—	—	—	—	2	0
[1]Attalla, Ala.	—	5	4	1	2	—	1	—	—	6	7
[1]Como, Miss.	—	—	—	—	—	1	35	14	69	15	104
Totals										1697	741

[1] New locality records.
[2] One specimen at Durham in May.
[3] One specimen at Durham in June.
[4] Five specimenst at Monroe in June.

lina and Alabama (King *et al.*, 1943). This work has been continued and data carrying through October 1943 are listed in this paper. While they do not extend the range of *C. pipiens* any farther south than the 1942 records, they establish its presence in northern Mississippi and also tend to fill in the gaps left by the 1942 surveys.

Figure 1, summarizing the 1942 and 1943 records in map form, gives a general picture of the range during those years. These records form the basis for presenting the probable southern range of *C. pipiens* which is indicated on the map. Table 1 gives the actual numbers of both *C. pipiens* and *C. quinquefasciatus* males which were determined, by an examination of the genitalia, from May through October 1943, in those survey areas where *C. pipiens* was found to be present. This is in no way an attempt to show the northern extension of the range of *C. quinquefasciatus*, but is merely to give an idea of the prevalence of *C. pipiens* as compared with *C. quinquefasciatus* throughout that part of the Fourth Service Command where the ranges of the two species overlap.

The records are not as complete as could be desired, since in some cases during the early part of this work a large proportion of the male *Culex quinquefasciatus-pipiens* complex received for identification were not determined by genitalia and therefore could not be included here. As the southern records began to show up, the importance of studying the male genitalia became more apparent. At the present time a large proportion of the male specimens of this group within the probable range indicated on figure 1 are so identified, and in the future it is desired to run the genitalia of male specimens collected farther south.—12-4-43.

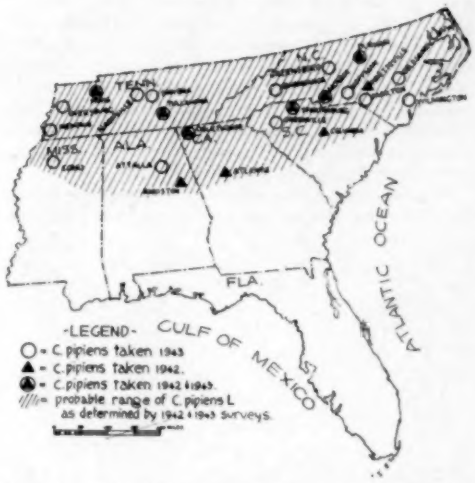

FIG. 1.—Probable range of *C. pipiens* L. in the southeastern States comprising the Fourth Service Command.

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Inland Records of Salt Marsh Mosquitoes

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Three species of salt marsh mosquitoes, *Anopheles atropos* (D. & K.), *Aëdes sollicitans* (Walk.), and *A. taeniorhynchus* (Wied.), are common in the southeastern United States. Both of the latter species are known to fly extremely long distances from their breeding places but an inland record does not necessarily mean that the specimen flew to that spot. Due to the abundance of these mosquitoes in many of the coastal areas, they may frequently be carried to inland places by means of aircraft and other modes of transportation. *Aedes sollicitans* and *A. taeniorhynchus* have been observed in many inland localities in the United States where they were breeding in salt water from oil wells (Carpenter 1941), in brackish water swamps (Roseboom 1942) and even in relatively freshwater. King *et al.* (1942) found many larvae of *A. taeniorhynchus* in a fresh-water pool in Orlando, Fla., which is about 30 miles from the coastal marshes. Barnett (1943, personal communication) found the larvae of *A. sollicitans* in a relatively fresh-water pool near Gulfport, Miss. A laboratory analysis of water from this pool showed 102 ppm NaCl.

Approximately 745,000 adult mosquito specimens have been identified in the Entomology Section of the Fourth Service Command Medical Laboratory during 1942 and 1943. Specimens were received from approximately 60 stations during 1942 and 142 stations during 1943 most of which submitted weekly collections. During this extensive mosquito collection program many inland records of *Aëdes sollicitans*, *A. taeniorhynchus*, and *Anopheles atropos* have been obtained. The locations of these collections are shown on a map of the Southeastern United States with scale of miles indicated (Fig. 1).

Specimens of *Aëdes sollicitans* were received from the following inland places during 1942: Hattiesburg, Miss., Hinesville, Ga., Orangeburg, S. C., Sebring, Fla., Starke, Fla., and Tallahassee, Fla. Inland records of *A. taeniorhynchus* were obtained from Hinesville, Ga., Monroe, N. C., Sebring, Fla. and Starke, Fla. during 1942. A single specimen of *A. sollicitans* taken in a light at Camp Robinson, Ark. on Oct. 13, 1942 was sent to the Fourth Service Command Laboratory for identification.—12-16-43.

FIG. 1.—Inland collections of salt marsh mosquitoes obtained by Fourth Service Command Laboratory during 1942–43.

[1] Major, Sanitary Corps, Armies of the United States.
[2] Captain, Sanitary Corps, Armies of the United States.

Table 1.—Inland collections of salt marsh species during 1943, arranged according to species, locality, date, number and sex. The collections are listed according to type indicated by the following symbols: (T) = light trap (New Jersey type); (R) = resting station; (B) = biting.

SPECIES AND LOCALITY	INCLUSIVE DATES OF COLLECTIONS	SPECIMENS AND COLLECTION METHODS
Anopheles atropos		
Dothan, Ala.	May 28	1 ♀ (T)
Starke, Fla.	June 1	1 ♀ (T)
Hinesville, Ga.	May 31	1 ♀ (T)
Hattiesburg, Miss.	June 4	1 ♀ (T)
Aëdes sollicitans		
Montgomery, Ala.	July 12–14	3 ♀ (T)
Orlando, Fla.	Oct. 8	1 ♀ (R)
Pinecastle, Fla.	Aug. 28	3 ♀ (R)
Sebring, Fla.	Apr. 2–Oct. 8	1 ♂, 38 ♀ (T); 6 ♀ (B)
Starke, Fla.	May 28–Aug. 30	1 ♀ (B); 1 ♂, 5 ♀ (T)
Tallahassee, Fla.	May 24–July 7	10 ♀ (T)
Hinesville, Ga.	May 3–Oct. 1	1 ♂, 23 ♀ (T)
Greenville, Miss.	June 18	1 ♀ (T)
Hattiesburg, Miss.	Aug. 2–Sept. 17	2 ♀ (T)
Goldsboro, N. C.	July 7–8	1 ♀ (T); 2 ♀ (R)
Hoffman, N. C.	June 28	1 ♀ (T)
Maxton, N. C.	July 7–10	3 ♀ (R)
Columbia, S. C.	May 28	1 ♀ (T)
Orangeburg, S. C.	July 22	1 ♀ (T)
Aëdes taeniorhynchus		
Attalla, Ala.	Oct. 1	1 ♀ (T)
Apopka, Fla.	July 18–27	1 ♀ (B); 2 ♀ (B)
Dunnellon, Fla.	May 14	1 ♀ (R)
Eustis, Fla.	July 9	1 ♀ (R)
Gotha, Fla.	June 5–29	5 ♀ (R)
Keystone Heights, Fla.	July 10	1 ♀ (B)
Montbrook, Fla.	Aug. 19	1 ♀ (R)
Mount Dora, Fla.	July 15	2 ♀ (R)
Ocoee, Fla.	June 29	1 ♀ (R)
Orlando, Fla.	Aug. 13–Oct. 1	1 ♀ (B); 3 ♀ (R)
Pinecastle, Fla.	July 19–Oct. 23	2 ♀ (B); 4 ♀ (R)
Plant City, Fla.	Aug. 4	1 ♀ (R)
Sebring, Fla.	Jan. 12–Oct. 29	177 ♀ (B); 240 ♂, 5515 ♀ (R)
Starke, Fla.	May 8–Sept. 1	8 ♀ (B); 5 ♀ (R); 3 ♂, 16 ♀ (T)
Tallahassee, Fla.	June 14–Oct. 8	3 ♂, 5 ♀ (T)
Winter Garden, Fla.	July 26	1 ♀ (R)
Augusta, Ga.	Sept. 6	1 ♂ (T)
Hinesville, Ga.	May 17–Oct. 8	2 ♀ (B); 13 ♂, 35 ♂ (T)
Clinton, Miss.	Sept. 17	1 ♀ (R)
Hattiesburg, Miss.	Aug. 16–Sept. 3	2 ♀ (T)
Jackson, Miss.	July 5–Aug. 10	1 ♀ (R); 1 ♂, 10 ♀ (T)
Goldsboro, N. C.	Aug. 25	1 ♀ (
Hoffman, N. C.	Aug. 10	1 ♀ (B)
Maxton, N. C.	July 3	1 ♀ (R)
Columbia, S. C.	May 12–July 14	4 ♀ (T)
Spartanburg, S. C.	June 23	1 ♀ (T)

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Additional Mosquito Records for the Southeastern States

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The distribution of mosquito species in the Southeast was summarized by King, *et al.* (1942) and more recently a paper by King *et al.* (1943) has added several new distributional records for mosquitoes in that region. The present paper, which is in the nature of a supplement to those previous lists, includes chiefly records made by field personnel of the Office of Malaria Control in War Areas of the U. S. Public Health Service.

Sixteen new records of mosquito species occurrence in states of the Southeast are presented herein together with records increasing the known range of eight others in states where knowledge of the species is limited.

The method used by King, *et al.* (1943) in denoting method of collection by letters in parentheses has been followed, viz: (L) larval, (T) light trap, (B) biting, (R) reared adult, and (S) resting station. Other information includes, where known, the number of specimens, the sex, the date of collection (1942 unless otherwise shown), and the name of the collector. An asterisk (*) has been used to indicate new state records and a dagger (†) to indicate previously unpublished records furnished by the South Carolina State Board of Health.

Aëdes fulvus pallens Ross

* ALABAMA—Mobile: (L), July 20, D. E. McBrayer.

Aëdes mitchellae (Dyer)

SOUTH CAROLINA—Camden: Aug. 31–Sept. 5. Columbia: (T), July 13–18, Aug. 31–Sept. 5. Florence: Nov. 10. Georgetown: Sept. 19, 1933,† Nov. 2–7, 1942, W. K. Lawlor and others. Gourdin: Aug. 24–Sept. 5. Montmorenci: 3, June 17, 1933, det. A. Stone.† Myrtle Beach: Nov. 9–14. Orangeburg: June 28. Sumter: July 27–Aug. 1. Witherbee: Aug. 1934, A. A. Weathersbee.†

Aëdes sticticus (Meig.)

LOUISIANA—Camp Beauregard, Rapides Parish: (B, R) 2♂, 24♀, April 3, 17, W. W. Wirth (woodland pools near Bayou Flagon, associated with *Aedes vexans, psorophora ferox* and *Culex apicalis*). Camp Livingston, Rapides Parish: (B) 12 ♀, April 11, W. W. Wirth. Ruston: 1♀, May 10, 1941, W. W. Wirth. SOUTH CAROLINA—Georgetown: 4, Sept. 6–8, 1933, det. A. Stone.†

Aëdes thibaulti D. & K.

*SOUTH CAROLINA—Orangeburg: May 6, S. Suib.

Aëdes tormentor D. & K.

*NORTH CAROLINA—Cherry Point: (L) 1, Aug. 17, L. A. Whitford.

Aëdes trivittatus (Coq.)

*SOUTH CAROLINA—Georgetown: 2, Sept. 7, 1933, det. A. Stone.†

Anopheles sp.—probably *albimanus* Wied.

FLORIDA—West Palm Beach: (S) 1♀, Aug. 19, 1943, E. V. Welch. (A special note on this specimen is being prepared for publication by Mr. Welch.)

Anopheles bradleyi King

*NORTH CAROLINA—New Bern: (L), Aug. 28. Tar Landing: (L), Sept. 10, D. Ashton and H. F. Schoof.

Anopheles georgianus King

FLORIDA—Arcadia: (L) 2, Dec. 21, M. W. Provost. Green Cove Springs: (L) 11, Aug. 3, 17. Jacksonville: (L) 89, June 6–Nov. 16, J. A. Mulrennan.

Anopheles walkeri Theob.

*SOUTH CAROLINA—Branchville: (L), date unknown, det. F. T. Arnold.† Orangeburg: date unknown, B. Birnie.† * NORTH CAROLINA—Chub Lake: (S) 1♀, (R) 2♀, (L) 4, Sept. 22, H. F. Schoof.

Culex pipiens L.

SOUTH CAROLINA—Central: Oct. 1, 1931, det. W. K. Lawlor.† Clemson College: Nov. 9, 1939, F. T. Arnold.†

Culex tarsalis Coq.

*FLORIDA—Pensacola: (T) 1♀, Sept. 29. TENNESSEE—Cordova: (T) 1♀, Aug. 31, M. B. Nichols. Memphis: (T) 1♀, Sept. 25. Millington: (T) 2♂, 3♀, Sept. 25, Oct. 5, 8, 20, 21.

Orthopodomyia alba Baker

*NORTH CAROLINA—Fort Bragg: (L), Sept. 18, H. F. Schoof.

Psorophora cyanescens (Coq.)

*SOUTH CAROLINA—Columbia: Sept. 14. *TENNESSEE—Chattanooga: (T) 2♀, Aug. 13, Sept. 20, S. G. Segal. Cordova: (T) 2♀, June 24. Aug. 18. Milan: (T) 2♀, July 20, 30. Paris: (T) 2♀. Sept. 1, 14. Union City: (T) 1♂, 7♀, Aug. 18, 20, Sept. 3, S. A. Carter. *NORTH CAROLINA—Swannanoa: (B) 1♀, Aug. 26, 1943. H. F. Schoof.

Psorophora horrida (D. & K.)

*LOUISIANA—Baton Rouge: (B) 43♀, June 9, 11, July 1, 1941, May 10, 1942, W. W. Wirth. Camp Claiborne, Rapides Parish: (B) 5♀, May 11, W. W. Wirth. Leesville: (B) 1♀, May 19, W. W. Wirth. *SOUTH CAROLINA—Columbia: July 17.

Psorophora varipes (Coq.)

*SOUTH CAROLINA—Orangeburg: (T) 2, July 13–18.

Theobaldia inornata (Will.)

TENNESSEE—Chattanooga: (T) 1♀, Sept. 26. Cordova: (T) 65♀, Sept. 24–Nov. 6. Memphis: (T) 27♀, Oct. 21–Nov. 6. Milan: (T) 6♀, Oct. 12–24. Millington: (T) 127♀, Sept. 22–Nov. 6.

Uranotaenia lowii Theob.

*ARKANSAS—Hope: (T), Aug. 13, 14.

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A Preliminary List of the Mosquitoes of Indiana

GORDON R. CHRISTENSEN[1] and
FRED C. HARMSTON[2,3]

This paper presents a list of the mosquito species taken in Indiana by personnel attached to the Malaria Control in War Areas program during 1941 and 1942 and is not to be considered as a complete list for the state. As this program continues, it is intended to add supplements from time to time as new species are found. Several of the species listed have not been recorded previously from Indiana.

Table 1.—Indiana mosquitoes, showing their prevalence and economic importance.

Aëdes aegypti (Linn.)	1[1]
canadensis Theo.	2
sollicitans Walk.	2
sticticus (Meig.)	4
triseriatus Say	3
trivittatus Coq.	2
vexans Meig.	2
Anopheles barberi Coq.	4
crucians Wied.	4
punctipennis Say	3
quadrimaculatus Say	1
walkeri Theo.	4
Culex apicalis Adams	3
erraticus D & K	3
pipiens Linn.	2
restuans Theo.	3
tarsalis Coq.	2
Mansonia perturbans (Walk.)	4
Orthopodomyia signifera (Coq.)	4
Psorophora ciliata (Fab.)	2
columbiae (D & K)	2
cyanescens (Coq.)	4
ferox (Humb.)	2
horrida Dyar	4
howardii Coq.	4
varipes (Coq.)	4
Theobaldia inornata (Will.)	3
morsitans Theo.	4
Uranotaenia sapphirina (O-S)	3

[1] 1. Important economic species.
2. Locally abundant and annoying.
3. Common species, not very troublesome, some non-biters.
4. Usually rare or very restricted distribution.

Aëdes aegypti (Linn.), Clark County—Sept. 10, 1941, E. V. Kemp; Vigo County—Sept., Oct., Nov., Dec., 1942, Jan., 1943. During the months from August, 1942, to January, 1943, several indoor biting catches were made of *Aedes aegypti* in residences in Terre Haute, Indiana, On January 6, in one residence, an adult had just emerged from water in an open bowl containing an aquatic plant. No larvae were present but nine pupal cases were counted. On January 21, four pupae and eight larvae were taken. On January 28, 1943, four larvae were taken. All produced *Aedes aegypti* adults. On September 10, 1941, several adult *Aedes aegypti* were reared from larvae taken from water-filled tin cans near Pleasant Run Creek in Charlestown, Indiana (Clark County).

Aëdes canadensis Theo., Martin County—April 23, 1942, G. R. Christensen. Several adults were reared from larvae of *A. canadensis* taken from a quiet, partially-shaded pool connected to a stream on the Burns City Naval Ammunition Depot reservation April 23, 1942.

Aëdes sollicitans Walk., Vanderburgh County—E. V. Kemp. On Oct. 8–10, 1941, adults of this species were abundant and large numbers of larvae were found in salt water ponds in Burdette Park near Evansville, Indiana (Vanderburgh County). The source of the salt water is a well that pumps about 100 g.p.m. during the summer (about 90 days) for feeding a salt water swimming pool in the park. It has been in existence since 1926. The overflow from the pool enters a lake, several ponds, a marsh, and finally empties into a creek. Samples of the water taken at seven different points starting from the lake below the swimming pool to the creek showed from 10,200 to 2,600 p.p.m. chlorides and the pH varied from 8.3 to 7.2.

Aëdes sticticus (Meig.), Martin County—April 23, 1942, G. R. Christensen; Jefferson County—July, 1942. Several *A. sticticus* larvae were taken April 23, 1942, from a quiet, partially shaded pool in the Burns City Naval Ammunition Depot reservation. The adults were reared and identified.

Aëdes triseriatus Say, Marion County—July 27, 1942, J. W. Hart; October, 1942; Vigo County—August, September, 1942; Jackson County—August, 1942. Mosquitoes of this species were taken while biting in a woods in Jackson County August 28, 1942 and in light traps at Walton Lake, West Terre Haute, August and September, 1942, and at Fort Benjamin Harrison, October 3, 1942. *Aedes triseriatus* breeds in tree holes.

Aëdes trivittatus Coq., Vigo County—September 28, 1942, R. K. Lenn, October, 1942, Marion County—September, 1942. Taken in light traps at Fort Benjamin Harrison on September 30, 1942, and at West Terre Haute. It breeds in rain-filled woodland pools.

Aëdes vexans Meig., Marion County—August, September, October, 1942; Vigo County—August, September, October, 1942; Clark County—May, August, September, 1942; Jackson County—August, 1942.

Anopheles barberi Coq., Marion County—August 12, 1942, F. C. Harmston & S. E. Arnold, September, October, 1942, June, 1943; Vigo County—August, October, 1942; Allen County—June, July, 1943. This tree-hole breeder was taken in light traps at Fort Benjamin Harrison during August, September, and October, 1942, and around Terre Haute during August, and October, 1942.

Anopheles crucians Wied., Vigo County—June 28, 1943, F. C. Harmston, July, 1943. *A. crucians* was first taken in the State of Indiana in a light trap at West Terre Haute, Vigo County, on June 28, 1943.

Anopheles punctipennis Say, Allen County—May, September, October, December, 1941, October, 1942, Vermillion County—December, 1941, July, 1942; Johnson County—August, 1942; Bartholomew

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[3] The authors desire to thank all of their associates who by their willing collaboration have made this paper possible.

County—August, 1942; Vanderburgh County—August, 1942; Jefferson County—July, September, November, 1941, July, 1942; Clark, County—September, 1941, July, August, September, October, November, 1942; Marion County—September, October, 1941, August, September, October, November, December, 1942, January, 1943; LaPorte County—August, September, October, December, 1941, October, 1942; Vigo County—July, August, September, October, November, December, 1942, January, 1943; Hendricks County—July, 1942; Clay County—July, 1942.

Anopheles quadrimaculatus Say, Jefferson County—November, December, 1941, July, 1942; Clark County—December, 1941, May, July, August, September, October, November, 1942; Vanderburgh County—August, 1942; Allen County—October, 1942; LaPorte County—December, 1941, October, 1942; Vermillion County—July, 1942; Marion County—September, October, 1941, August, September, October, November, 1942; Vigo County—July, August, September, October, November, December, 1942; Hendricks County—July, 1942; Clay County—July, 1942.

Anopheles walkeri Theo., *Anopheles walkeri* was first taken in Indiana June 11, 1943, in a light trap at Baer Field near Fort Wayne, Allen County, by F. C. Harmston.

Culex apicalis Adams, Marion County—September, October, 1942; Clark County—August, September, 1942; Vigo County—August, September, October, 1942.

Culex erraticus D. & K., Marion County—July 22, 1942, J. W. Hart and G. R. Christensen, August, September, October, 1942; Vigo County—September, October, 1942; Vanderburgh County—August, 1942; Clark County—July, 1942. This common species of the subgenus *Melanoconion* was taken in light traps and natural resting places in the southern half of the state, and probably is of statewide distribution. It apparently occurs in greatest abundance during late summer. Determinations were made from male terminalia preparations, as the female cannot be identified with certainty.

Culex pipiens Linn., Vigo County—July, August, October, 1942; Marion County—October, 1942; Clark County—September, 1942.

Culex restuans Theo., Marion County—August, September, OMtober, 1942; Clark County—August, September, 1942; Vigo County—August, September, October, 1942; Hendricks County—July, 1942.

Culex tarsalis Coq., Marion County—September, October, 1942; Clark County—August, 1942; Vigo County—September, October, 1942.

Mansonia perturbans (Walk.), Marion County—September, 1942; Vigo County—August, September, October, 1942.

Orthopodomyia signifera (Coq.), Marion County—August 22, 1942, S. E. Arnold and J. W. Hart, October, 1942. Two females of this rare tree-hole breeding species were taken in light traps in Marion County, one in late August, and the other on October 1. It is a strikingly marked mosquito, the narrow white stripes on the mesonotum strongly contrasting against the black ground color.

Psorophora ciliata (Fab.), Marion County—August, September, October, 1942; Clark County—August, September, 1942; Vigo County—July, August, October, 1942; Jefferson County—July, 1942.

Psorophora columbiae (D. & K.), Clark County—August 22, 1942, J. W. Hart & G. R. Christensen, September, 1942; Marion County—September, October, 1942; Vigo County—August, 1942. *P. columbiae* was collected during 1942 in late summer and early fall in Clark, Marion, and Vigo Counties. The females are severe biters but its rarity in Indiana makes it of little economic importance.

Psorophora cyanescens (Coq.), Clark County—June, 1943.

Psorophora ferox (Humb.), Clark County—May, July, August, 1942; Martin County—April, 1942; Jackson County—Aug., 1942; Marion County—August, September, October, 1942; Vigo County—August, September, October, 1942; Scott County—August, 1942; Jefferson County—July, 1942.

Psorophora horrida Dyar, Clark County—May, 1942; Marion County—September, October, 1942; Vigo County—August, October, 1942.

Psorophora howardii Coq., Jefferson County—July 18, 1942, J. W. Hart, J. A. Rowe, J. F. Field, and G. R. Christensen. One female of this large species was taken while biting in Jefferson County during mid July. It is apparently rare in Indiana. In size it is similar to *P. ciliata* but has a general bluish color rather than yellow.

Psorophora varipes (Coq.), County and date unknown, J. W. Hart.

Theobaldia inornata (Will.), Marion County—August, September, October, 1942; Clark County—August, 1942; Vigo County—August, September, October, 1942.

Theobaldia morsitans Theo., Vigo County—October 2, 1942, F. C. Harmston. A single female specimen of this species was taken in a natural resting place at West Terre Haute, October 2, 1942. The species is rare in this state and of little economic importance.

Uranotaenia sapphirina (O.-S.), Marion County—October 15, 1941, E. V. Kemp & G. R. Christensen, August, September, October, 1942; Clark County—August, September, 1942; Vigo County—August, September, October, 1942. This small species was common in light trap collections during late summer and early fall. The iridescent blue scales of mesonotum, pleura and wings make identification easy.—10-13-43.

The Toxicity of Cyclopropyl Alkyl Ethers and Trichloromethanesulfonyl Chloride to the Confused Flour Beetle

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CYCLOPROPYL ALKYL ETHERS.—Cyclopropyl methyl ether, commercially known as Cyprome, has been shown recently to be anesthetic to many species of animals (KIANTZ *et al.* 1940). It is a colorless liquid with a boiling point of 43.5–44° C.

This compound and its ethyl and propyl homologs[1] have been tested as fumigants against the confused flour beetle, *Tribolium confusum* Duv. Each compound was tested at 6 to 8 concentrations using from 50 to 100 beetles per test, by a method described by Richardson & Casanges (1942). The approximate concentrations to kill 50 and 95 per cent

[1] Samples were obtained through the courtesy of N. L. Drake, of the University of Maryland.

of the insects were determined from freehand curves drawn on logarithmic probability paper. The results are given in table 1, together with similar data for carbon disulfide as a standard.

Table 1.—Toxicity of cyclopropyl alkyl ethers as fumigants for the confused flour beetle, as compared with carbon disulfide as a standard. 5-hour exposures at 25° C. Mortality results taken after 10 to 20 days.

Material	Approximate Concentration (Milligrams per Liter) to Give Mortality of—	
	50 Per Cent	95 Per Cent
Cyclopropyl methyl ether ($C_3H_5OCH_3$)	82	105
Cyclopropyl ethyl ether ($C_3H_5OC_2H_5$)	40	50
Cyclopropyl propyl ether ($C_3H_5OC_3H_7$)	72	90
Carbon disulfide (CS_2)	56	100

Cyclopropyl ethyl ether was the most toxic of the three ethers. In these preliminary tests it appeared to have some delayed killing action similar to that of ethylene dichloride (Richardson & Casanges 1942). The toxicity of the other two ethers was near that of carbon disulfide, as indicated by the 95 per cent mortality.

Trichloromethanesulfonyl Chloride.—An emulsion of trichloromethanesulfonyl chloride, Cl_3CSO_2Cl, was used by Pelikh (1937) for the treatment of soil against the sugar beet weevil, and found to be cheaper than chloropicrin or carbon disulfide. This compound, a white crystalline solid, has been prepared by Schechter & Haller (1941). It was compared with *p*-dichlorobenzene as a fumigant for the confused flour beetle. The tests were made in an airflow apparatus similar to that used in studies of nicotine-naphthalene mixtures (Richardson 1940). The saturation concentration of trichloromethanesulfonyl chloride at 25° C. was found to be 8.30 milligrams and that of *p*-dichlorobenzene 8.02 milligrams per liter when the air flow was 6 liters per hour. These values are equivalent to vapor pressures of 0.70 and 1.01 mm. The value for trichloromethanesulfonyl chloride is 2.9 per cent of the vapor pressure of chloropicrin at this temperature. At lower temperatures, which sometimes occur in soils, the percentage may be smaller, possibly near 0.160 per cent, as given by Pelikh.

In a series of nine paired tests at exposures of 1 to 2.5 hours with saturation concentrations, the average kill after 20 days was 24.3 per cent for trichloromethanesulfonylchloride, and 47.1 per cent for *p*-dichlorobenzene. The average difference in favor of *p*-dichlorobenzene was 22.8 ± 4.2 per cent. Both chemicals had some latent toxic effect which increased the mortality slightly from the 4th to the 20th day after fumigation.

Tests at various concentrations indicated that approximately 5.7 and 8.3 milligrams of trichloromethanesulfonyl chloride per liter were needed to give 50 and 90 per cent kill, respectively, in 5-hour exposures at 25° C. With only half this exposure *p*-dichlorobenzene killed nearly 90 per cent at 8.02 milligrams per liter. *p*-Dichlorobenzene appeared definitely more toxic to the flour beetle.—10-28-43.

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Armyworms in Georgia[1]

Theodore L. Bissell, *Georgia Experiment Station, Experiment*

In 1943 local outbreaks of the true armyworm, *Cirphis unipuncta* (Haw.), occurred at several points in central Georgia. The insect usually goes unnoticed as I have never seen its work before and the Insect Pest Survey Bulletin contains only one report from the state from 1921 to 1942. This cites damage to corn at Marietta in September 1924 and was made by V. C. Durham. Notwithstanding this rare activity records at Experiment on adults and hibernating larvae show that the species is continuously present.

Late in July 1943 a heavy infestation developed in Henry County where a field of brown top millet, ready to cut for hay, was stripped of leaves. Damage was well advanced before the worms were noticed. When first seen (on a cloudy day) great numbers of worms were crawling about between the millet plants and across a roadway and dry ditches between two fields. They did not seem to be marching in any one direction. At one point worms were crawling up and down a ditchbank 30 inches high and practically perpendicular. This activity seemed to discount the value of ditch barriers for armyworms.

In this locality millet was the only crop damaged. Crab grass in an adjacent cotton field was cleaned out by the worms without touching the cotton. In lespedeza along the roads one could rarely find a leaf with marks of feeding.

Excellent control of the armyworms in Henry County was secured with poison bran bait, 25 pounds wheat bran, 1 pound paris green, with 2 gallons of water. One hundred and fifty pounds was spread over six acres of millet. The next day dead worms were very numerous and in 2 days the decaying bodies made a heavy stench. A few live worms could be found under bunches of fallen grass.

In one batch of poison bait sodium fluosilicate was substituted for paris green. The two poisons gave

[1] Paper No. 120, Journal Series, Georgia Experiment Station.

similar results in the field and in laboratory tests. Of 100 worms caged in petri dishes and fed sodium fluosilicate bran mixture 80 died in 2.5 hours and 18 more died by the following morning. Of 100 fed paris green with bran 76 died in 2.5 hours and 20 more during the night. Of 150 worms fed grass without poison none died during the experimental period.

On August 17 large numbers of armyworms were found stripping the lower leaves of maturing corn on bottom land in the northeastern corner of Fulton County. The worms had also fed extensively on Johnson grass. The corn ears were developed enough to be safe from much loss.

Armyworms were sent to the laboratory with lespedeza from Douglas County on August 24, but it is presumed they were feeding on grass. Larvae of the same species were readily found on millet and crab grass at Experiment in August 1943, but no appreciable damage was noticed at this point.

FIG. 1.—Top of cornstalk infested by fall armyworm, August 17.

Each winter from 1936 to 1940, during the course of hibernation studies on certain Coleoptera (Bissell 1939), armyworms were collected at Experiment in ground cover. They were found in dead grass and leaves under pecan trees, on terraces, in broomsedge, and in litter from cowpea hay. Most of the worms were taken in January, February, and March; some in December and April. One larva collected February 24, then in the penultimate instar, pupated and the adult emerged May 13.

The moth of *Cirphus unipuncta* is one of the most common species caught in *Monolite* light traps which have been operated every year since 1937. The earliest collection has been March 3, the latest December 5. Moths were especially abundant in 1938 when 977 were caught in two traps between September 28 and November 21. They have always been most numerous in the fall.

Activity of the fall armyworm, *Laphygma frugiperda* (A. & S.), in Spalding County and nearby territory has been recorded every year from 1934 to 1943. Worm. usually first become noticeable the latter part of July, increase in August and September, and continue damage in October. However, larvae were found attacking corn May 19, 1939 and again May 27, 1940. These produced moths[1] June 10, 1939 and June 12, 1940. The earliest seasonal record of the species is May 8 (1938) when a male moth,[1] with unusually pale scales on the thorax ,was taken at light. Small numbers of moths have been taken in light traps in the fall, the latest record being November 6 (1943).

Crops found infested during the 10 years have been: corn 21 reports, cowpea 5, pepper 3, grass 3, dahlia 2, and collards, cotton, gladiolus, millet, and peanut, 1 report each. The fall armyworm is a serious pest of late corn in Georgia, feeding in the opening leaves or "bud" and on the tassel (Fig. 1). It appears that plants about waist high are favored for oviposition and that grass need not be a factor in the establishment of this pest.

For identifying armyworms and fall armyworms many characters have been pointed out. Crumb (1927) gives a key and descriptions for larvae of the armyworm habit. Garman (1920) has excellent photographs comparing the markings of the two armyworms and other species of noctuid larvae. The distinguishing characters that have been found most useful are: head with brown network in *C. unipuncta;* network in *L. frugiperda* obscured with darker brown coloring, and a yellow inverted Y on the face. Mandible of *C. unipuncta* like an axe blade with two obscure teeth in the middle; mandible of *L. frugiperda* with five acute teeth. Skin of *C. unipuncta* smooth and pronotum shining; skin of *L. frugiperda* with granules evident under magnification of 22 and pronotum dull. Hair-bearing tubercles of full-grown *unipuncta* 0.10 to 0.15 mm. wide and tubercle 2 located in a dark longitudinal stripe; tubercle 2 of *L. frugiperda* 0.3 to 0.4 mm. wide and set in a comparatively light stripe. Pale stripe below tubercle 2 yellow or red in *unipuncta* narrowly bordered on each side with white; pale lateral stripe in *L. frugiperda* without white borders. Dark lateral stripe in *C. unipuncta* plain; in *L. frugiperda* with two white spots near the spiracle and sooty dashes on the upper edge.)11-1-43.

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[1] Moths identified by Mr. J. F. Gates Clarke.

A Slide Rule for Estimating Schedules for Fumigating with Methyl Bromide

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It was shown in a previous paper (English 1943) that the dosage, exposure, and temperature requirements for a complete kill of the scale insects, *Lepidosaphes camelliae* Hoke and *Fiorinia theae* Green, on camellias, were approximated by the equation, $DE = 40.23e^{-0.030T}$, when D is the dosage in pounds of methyl bromide per 1000 cubic feet, E is the exposure in hours, and T the temperature in degrees Fahrenheit. A nomograph was designed

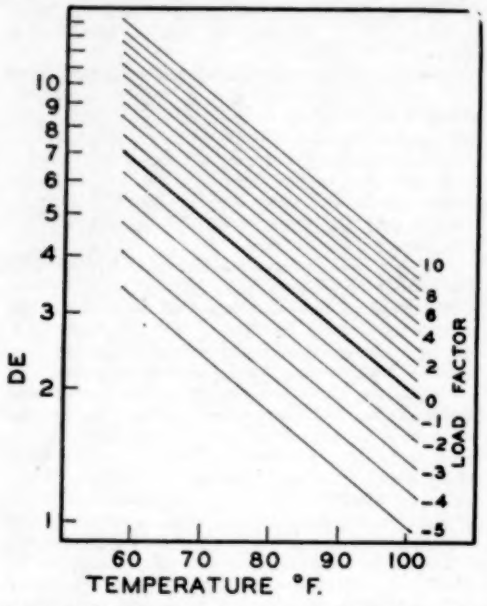

FIG. 1.—DE (dosage × exposure) plotted to logarithmic scale against temperature, using load-factors ranging from −5 to 10.

from this equation and it was pointed out that for commercial fumigation the exposures obtained from the nomograph should be increased about 25 per cent for a given dosage and temperature in order to insure a complete kill of the insects throughout a fully loaded chamber.

In reviewing the fumigation schedules recommended by other workers for a number of pests, particularly the extensive series of Mackie (1942), it was found that many of these schedules were essentially in agreement with those recommended for the scale insects on camellia. Most of the schedules now used by others cover a somewhat limited range of temperature. In practical fumigation it is desirable to know effective schedules over a range of temperature so that the fumigation chamber can be operated near the prevailing atmospheric temperature. This paper describes the construction and use of a slide rule which can serve as a guide to those who may wish to extend known fumigation schedules to a wider range of temperature.

It is assumed that the mathematical relationship, $DE = ae^{-bT}$, where a and b are constants, will apply to other pests as well as those investigated by the author. Hamilton's (1941) work with the common red spider, *Tetranychus telarius* (L.), established a similar relationship, and its possible application to other pests is worth exploring. The values of the constants a and b, may, of course, vary with the species of the pest, the fumigation chamber, and the conditions under which fumigation is carried out. In designing the slide rule, "load-factors" (F) have been provided which allow variation in the value of a to broaden the adaptation of the rule.

THE SLIDE RULE.—The details for the construction of the rule are essentially those given by Davis (1943). If the equation, $DE = 40.23e^{-0.030T}$, is expressed in logarithms, then,

$$\log D + \log E = \log 40.23 - 0.030T \log e$$
$$= \log 40.23 - 0.01303\ T.$$

A modulus of 12.8 centimeters was chosen for the scales, as this length was suitable and it is the modulus of the scales on *Dietzgen's* logarithmic paper *No. 340-L2*. The D-, E-, and F-scales were constructed by fastening a strip of the logarithmic paper to the drawing board and extending the scale divisions to drawing paper with the aid of a T-square and a reading glass. This eliminated the task of calculating and measuring each division of these scales. Since the temperature scale is non-logarithmic, and the range is 60 to 100 degrees, the construction of the T-scale was obtained by the relationship,

$$\text{Length of } T = (12.8 \times 0.01303)(100 - 60) = 6.67 \text{ cm.}$$

$$\text{Each 1-degree division is then } \frac{6.67}{40}, \text{ or } 0.167 \text{ cm.}$$

In order to introduce a scale of load-factors, values of the constant a (40.23) were increased 10, 20, 30, · · · , 100 per cent by multiplying 40.23 by 1.1, 1.2, 1.3, etc. These values were located on the logarithmic scale and designated as load-factors 1, 2, 3, · · · , 10. Similarly, a was decreased to obtain load-factors of −1, −2, −3, −4, and −5, by multiplying 40.23 by 0.9, 0.8, 0.7, etc. Thus 40.23 = a load-factor of 0, 44.25 = a load-factor of 1, 48.27 = a load-factor of 2, 36.21 = a load-factor of −1 and so on. Hence the slide rule integrates the values represented by the series of parallel lines in figure 1.

When the construction of the scales was completed they were cut out and temporarily fastened to a blank rule with transparent tape. The blank rule was made by sanding the painted scale from an inexpensive slide rule.[1] Proper location of the scales was determined by trial. The scales were then redrawn, inked, and photographed. Prints were made on glossy paper, the scales were carefully cut out and glued to a blank rule. (Fig. 2)

DISCUSSION.—It should be emphasized that any new fumigation schedule should be verified experimentally. The data on which this slide rule was designed were obtained from experiments carried out in a tight chamber with accurate temperature-control equipment, a means for accurate measurement of the dosage, and with continuous circulation of the air-gas mixture. The usual procedure of providing adequate circulation of the air-gas mixture, avoiding overloading of the chamber, and pre-heating the load to a uniform temperature before introducing the gas, should be observed.

In using the slide rule, the selected load-factor, F, is set at the desired temperature on the scale T. The exposures, in hours, are then read on scale E and the dosages in pounds per 1000 cubic feet on scale D.

[1] Purchased at a "Ten-Cent" store for 25 cents.

The proper load-factor to use will depend on the equipment, the material being fumigated, and the pest. When a schedule has been established at one temperature, the slide rule can be set at the known temperature, dosage, and exposure, to obtain the unknown load-factor. This load-factor then may be used for estimating the dosage and exposure for other temperatures. For example, Mackie (1942) recommends a dosage of 2.5 pounds of methyl bromide for 2 hours at a temperature of 80–85° F. for a number of armored scale insects on nursery stock. Setting the slide rule for a dosage of 2.5 pounds, an exposure of 2 hours, and a temperature of 80 degrees, a load-factor of about 4 is obtained. Using this load-factor at a temperature of 70 degrees, the slide rule calculates an exposure of 3.4 hours for a dosage of 2 pounds. At 60 degrees a load-factor of 4 gives an exposure of 3.05 hours for a dosage of 3 pounds. These schedules are in excellent agreement with those recommended for the commercial fumigation of camellias infested with scale insects (English 1943). Mackie *et al.* (1942) recommend a dosage of 2 pounds of methyl bromide for 2.5 hours or 2.5 pounds for 2 hours at 70° F. for the fumigation of the European earwig, *Forficula auricularia* L., on nursery stock. These dosages and exposures give a load-factor of about 0.2 at a temperature of 70 degrees, which might be applied to other temperatures.[1]

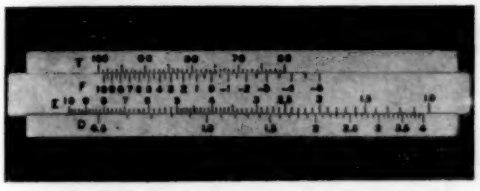

FIG. 2.—The completed slide rule.

In fumigating plants known to be quite tolerant to methyl bromide, a constant load-factor might be used throughout the whole temperature range. When the margin between the requirements for a complete insect kill and the tolerance limit of the plant is small, it would be advisable to decrease the load-factor with increasing temperature, since the margin of safety is known to decrease with increasing temperature. The recommended schedule for the commercial fumigation of camellias at 60° F. is 3 pounds for 3 hours, which gives a load-factor of 3.7 on the slide rule. For summer fumigation, when atmospheric and load temperatures were near 90° F., a dosage of 2 pounds for 1.5 hours was found satisfactory (English 1943). This schedule gives a load-factor of 1.2 on the slide rule. An approximate rule to follow, then, would be to decrease the load-factor about 1 for each 10-degree rise in temperature.

Use of the slide rule possibly could be extended to wider fumigation practice. Donohoe (1943) has set up five schedules for the fumigation of produce infested with the Japanese beetle, *Popillia japonica* Newm., in refrigerator cars. At 60° F. his recommendation is a dosage equivalent to 2.4 pounds per 1000 cubic feet for an exposure of 2 hours. The slide rule calculates a load-factor of −2.7 for this schedule. Using this load-factor for the other temperatures specified by Donohoe, it was found that

[1] The author will be glad to supply slide rules to a limited number of those who may be interested in their use.

Table 1.—Dosages of methyl bromide recommended by Donohoe for fumigating produce for the Japanese beetle in refrigerator cars compared with dosages calculated with the slide rule, using a load-factor of —2.7. Exposure period, 2 hours.

Minimum Temperature of Load and Enclosure °F.	Dosage, Lbs./1000 Cu. Ft.	
	Recommended by Donohoe	Calculated with Slide Rule
60	2.4	2.40
68	2.0	1.89
77	1.6	1.44
86	1.2	1.11
95	0.8	0.84

the dosages calculated with the slide rule approximated those recommended (Table 1), even though his data plot more correctly to a straight line. This rule, or one of similar design, might be adapted to the fumigation of food products, clothing, and other materials, if it is found that the fundamental relationships are valid. Load-factors could be specified for certain groups of insects, commodities, and types of chambers. Other investigations, however, may disclose a different slope for the base line and different values of the constants in the equation used for its design. Such being the case, slide rules could be readily designed to meet the particular problem. However, the limitations of the slide rule are recognized and it is not presented as a tool for universal methyl bromide fumigation, but rather, as stated in the beginning, to serve as a guide for those doing fumigation work.

SUMMARY.—The construction of a slide rule for use in fumigating plants with methyl bromide is described. The rule provides for the estimation of schedules covering a dosage range of 0.5 to 4 pounds of methyl bromide per 1000 cubic feet, an exposure range of 1 to 10 hours, and a temperature range of 60 to 100° F. A scale of load-factors permits a wide selection of fumigation schedules. The use and adaptation of the slide rule are discussed.—4-12-43.

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Anethole and Pimenta Leaf Oil as Attractants for the Japanese Beetle

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For a number of years a bait composed of commercial geraniol and U.S.P. eugenol has been considered to be the most attractive to the Japanese beetle, *Popillia japonica* Newman, and such a bait has been recommended for use in Japanese beetle traps.

The commercial geraniol has been obtained from citronella oil, a product imported largely from the Far East. Since 1941 it has not been possible to obtain the grade of geraniol used previously, and market reports indicate that little geraniol will be available in the near future. With regard to eugenol the situation has not been so critical and the outlook is brighter.

For several years an investigation has been in progress to determine what materials might be substituted for geraniol and for eugenol without decreasing significantly the attractiveness of the bait. Several hundred materials have been tested in the field as baits, among them anethole[1] and pimenta leaf oil. Tests with anethole and pimenta leaf oil were conducted during the summers of 1941, 1942, and 1943.

Table 1.—Attractiveness of geraniol, anethole, eugenol, and pimenta leaf oil baits to the Japanese beetle, each bait including two materials.

Composition of Bait		Number of Beetles Captured in 5 Traps During 6 Weeks	Comparative Capture
Material	Parts by volume		
Geraniol	90	62,042[1]	100
Eugenol	10		
Geraniol	90	63,643	103
Pimenta leaf oil	10		
Anethole	90	59,539	96
Eugenol	10		
Anethole	90	65,511	105
Pimenta leaf oil	10		

[1] Least significant difference with odds of 19 to 1 is 9810.

It is planned to present a detailed report of this investigation at a later date. This preliminary note has been prepared in order that the information regarding anethole and pimenta leaf oil may be available to those interested in procuring stocks of materials which could be substituted for geraniol and eugenol as baits for Japanese beetle traps.

Anethole, a natural constituent of anise oil, star anise oil, and fennel oil, is available at present in limited quantities from these sources. It is also prepared synthetically from domestic pine oil in large quantities. Pimenta leaf oil, an essential oil from the West Indies, is obtained by distillation of the leaves of *Pimenta officinalis*. Quotations obtained on October 15, 1943, on bulk lots of materials for use as baits were as follows: Anethole (derived from pine oil) $1.60 to $2.00 per pound, geraniol $2.50 per pound, eugenol $3.00 per pound, and pimenta leaf oil $4.80 to $5.25 per pound.

In testing the attractiveness of the baits, each bait was placed in 5 traps. The traps were arranged, 25 feet apart, in Latin squares containing 25 traps each, 20 traps of which contained four of the test baits and 5 traps the standard bait, redistilled U.S.P. eugenol. Each bait was tested in competition with several groups of other test baits. The number of beetles taken in the traps with each test bait wasdetermined at the end of each week and at the end of the season.

The results obtained with the different baits indicated that anethole, derived from pine oil and satisfying the requirements of the National Formulary, could be substituted for the geraniol, and that pimenta leaf oil could be substituted for the eugenol Some of the data obtained from tests with these materials as substitutes for geraniol and for eugenol are given in table 1.

There are no significant differences in the effectiveness of these four baits. As the results obtained in more extensive tests are in agreement with those presented here, it seems that anethole, derived from pine oil, can be substituted for geraniol, and that pimenta leaf oil can be substituted for eugenol, or that both geraniol and eugenol can be replaced by anethole and pimenta leaf oil without modifying significantly the value of the bait.

It was observed in the field that the rate of evaporation of the anethole baits was more than three times that of the geraniol baits. By decreasing the exposed surface of the wick it may be possible to reduce the rate of evaporation of the anethole baits without changing significantly the effectiveness, but this is a subject for further investigation.—11-29-42.

[1] Anethole was tested by F. W. Metzger at the Japanese Beetle Laboratory in 1931 in connection with geraniol and eugenol, but the results did not appear at that time to be sufficiently outstanding to warrant further tests. This material was included in 1941 in a list of materials suggested for test by H. L. J. Haller and H. A. Jones.

The Biology of *Triatoma neotomae* Neiva in Texas

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Probably the earliest record concerning the presence of *Triatoma neotomae* Neiva in Texas was by E. A. Schwarz in 1898. The Entomological Society of Washington. Schwarz (1901) referred to them as bloodsucking bugs without giving the identity. Hussey (1922) in a review of the genus *Triatoma* identifies the specimens of Schwarz collected in 1898 as *T. neotomae*. Neiva (1914) states the following: "The primitive habits of species of *Triatoma* are to occupy the nest of various mammals; thus *T. geniculata* occurs in the nests of the armadillo, *Dasypus novemcinctus;* while the North American *T. neotomae* has been taken only in the nests of the wood rat *Neotoma* . . ." Readio (1927) lists this species as being found in Texas and Arizona.

Specimens have been taken by the Texas State Health Department Bureau of Laboratories staff in 1942 and 1943 (de Shazo 1943). In Cameron and Willacy Counties, nests of *Neotoma* spp. were found infested with this species of *Triatoma*, as well as *Triatoma occulta* Neiva, *Triatoma protracta* (Uhler) and *Triatoma gerstaeckeri* (Stal). *Ornithodoros talaje* (Guerin-Meneville) infected with relapsing fever spirochaetes were taken from nests in which nymphs of *Triatoma neotomae* were collected. Feces of speci-

mens of *T. neotomae* from both counties were examined in the laboratory and found to harbor trypanosomes of Chagas' disease (de Shazo 1943).

An adult female collected September 23, 1942 in Cameron County deposited thirteen eggs after arriving in the laboratory. Eleven of these eggs were laid September 25 and two on September 27. The eggs hatched October 16 and 18 respectively after an incubation period of 21 days. The nymphs were allowed to take blood meals from rabbits at five day intervals and the first molts occurred November 5. The nymphs were fed at weekly intervals throughout the winter and spring. Molts into the fifth instar occurred in June and July. The first adult (male) emerged October 22, 1943 one year and 27 days after the first eggs were laid. At the time of emergence of the first adult the last fourth instar nymph molted into the fifth. Only two nymphs died during the entire period of study attesting to the hardiness of the species under laboratory conditions.

A fifth instar nymph weighed and fed, immediately after molting showed a 133.68% increase over the unfed weight. An adult showed an increase of 41.28%. The respective weights of the unfed fifth instar nymph and the adult male were 49.0 milligrams and 80.85 milligrams.

Hungry *Triatoma neotomae* readily take blood from rats, guinea pigs, rabbits and man. No attempts have been made to transmit *Trypanosoma cruzi* with this species.—12-4-43.

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Toxicity of Nitroparaffins and Chlorinated Nitroparaffins to California Red Scale and Their Effect on Lemon Fruits

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Recently O'Kane (1941) suggested the possible use of 1,1-dichloro-1-nitroethane as a fumigant. Since commercial developments of methods of nitrating hydrocarbons have made a series of nitro compounds available in quantity, tests were performed at the Whittier, Calif., laboratory to determine the relative toxicity of a series of nitroparaffins and chlorinated nitroparaffins to the California red scale, *Aonidiella aurantii* (Mask.). The tests included nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1-chloro-1-nitroethane, 1,1-dichloro-1-nitroethane, 1-chloro-1-nitropropane, and 1,1-dichloro-1-nitropropane.

Five tests were made with each compound against mature female red scales on lemon fruits. With a concentration of 20 milligrams per liter one test was made at 59°, two at 77°, and one at 90° F. Another test was made with a 40 milligram concentration at 59° F. Insects were killed in all tests with the chlorinated compounds, but the concentrations necessary to give a satisfactory control injured the fruits in every case but one. Severe injury to the fruits resulted from the use of all chlorinated compounds at 59° and 77° F. At 90° F. no injury was detected on the lemons fumigated with 1,1-dichloro-1-nitropropane, but the other chlorinated compounds caused injury. At equal concentrations there was more severe injury from the monochloro compounds than from the dichloro nitroparaffins.

No significant mortality was obtained with the nitroparaffins, namely, nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane. No injury was detected with these compounds.—12-1-43.

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The Use of D-D Mixture Against *Anomala* and *Adoretus* Infesting Nursery Stock[1]

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The following data were obtained in small scale tests to determine whether a mixture of 1–3 Dichloropropylene and 1–2 Dichloropropane, known as D-D mixture, could be used in lieu of other fumigants for the purpose of controlling ground beetle larvae in the soil around the roots of nursery stock. No dormant stock was available for this purpose, so actively growing plants of the following species were used:

Galphima (*Thryallis glauca*)
Plumbago (*Plumbago auriculata*)
Mock orange (*Murraya exotica*)
Shower tree (*Cassia* species)
Beloperone species
Mangosteen (*Garcinia mangostana*)
Cinchona ledgeriana

An emulsion of crude D-D mixture was made up as follows: 100 cc. of water were first mixed with 5 gms. of bentonite and then a mixture of 60 cc. crude D-D mixture with 40 cc. of Diesel oil 27+ was stirred into the water-bentonite mix, using a high speed mixer. This emulsion was then diluted at the rate of 0.5, 1 and 2 per cent and the cans in which the nursery stock was growing were then plunged into the diluted emulsions and set aside to drain. At all these three dilutions the nursery stock was seriously injured.

A parallel series of cans containing *Anomala orientalis* (Waterh.) and *Adoretus sinicus* Burm. were similarly treated, with a 100 per cent mortality of the insects resulting. The emulsions were then abandoned, and a simple saturated water solution of D-D made up. Roughly, 2 cc. will saturate a liter of water, but it is easy to maintain a saturated solution since the D-D mixture sinks to the bottom and the

[1] Published with the approval of the Acting Director as Technical Paper No. 150 of the Pineapple Research Institute.

Table 1.—Fumigation of *Anomala* and *Adoretus* larvae with diluted saturated water solutions of D-D mixture which did not injure actively growing nursery stock.

	Dilution	No. of Larvae Used	Dead	Alive
Anomala	1:2	5	5	0
		5	5	0
		5	5	0
	1:4	5	5	
		5	5	
		5	4	1[1]
Check	—	20	0	20
Adoretus	1:2	5	5	0
		5	5	0
		5	5	0
	1:4	5	5	0
		5	5	0
		5	5	0
Check	—	30	0	30

[1] Dying.

supernatant saturated water can be readily decanted off for use. Treatment of nursery stock by watering each can with 500 cc. of this saturated water solution again resulted in serious injury to the plants and complete kill of the *Anomala* and *Adoretus* larvae.

A third series of the nursery stock was then treated with the saturated water solution diluted with an equal quantity of water. At this concentration, no injury resulted to the nursery stock. Additional fumigations were then made of *Anomala* and *Adoretus* in similar cans of soil, using the saturated water solution diluted with equal quantities of water, and also at the rate of one part of saturated water solution in four. After approximately 48 hours, all the larvae were dead except one *Anomala* larva in the 1 in 4 series and it was showing only faint signs of life. These data are shown in the accompanying table. Additional tests with *Anomala* larvae were then made, using dilutions of the saturated water solution up to 1 in 10, but dilutions greater than 1 in 4 failed to kill all the larvae.

It is strongly indicated from these data that D-D mixture will prove useful to nurserymen, particularly those concerned in interstate shipments of living plants.—12-2-43.

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Pentatomidae Eaten by Utah Birds

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The hemipterous family Pentatomidae consists of large to small species. Because of the distinct odor given off by members of this family, they often are referred to as "stink bugs." Many of the species cause serious to minor injury to crop plants; a few should be considered beneficial because of their feeding upon and destroying injurious caterpillers, Colorado potato beetle larvae, and other injurious insects. Pentatomids seldom were observed to be abundant in the semidesert areas of Utah in which many of the birds collected in this study were found.

Table 1.—The following table lists 33 species of birds, one or more stomachs of which contained pentatomid bugs.

Bird Species	Pentatomidae Eaten	Total Bird Stomachs	
		Containing	Examined
Desert sparrow hawk	7	6	242
Sage grouse	23	6	17
Ring-neck pheasant	3	3	14
Poorwill	3	1	2
Eastern kingbird	5	5	21
Arkansas kingbird	18	14	101
Say phoebe	9	7	23
Hammond flycatcher	3	1	4
Desert horned lark	1	1	178
Violet-green swallow	2	2	14
Barn swallow	30	14	59
Magpie	30	4	22
Pinion jay	2	1	3
House wren	4	1	4
Rock wren	49	20	63
Sage thrasher	21	20	110
Western robin	2	2	29
Mt. bluebird	25	20	177
Townsend solitaire	1	1	6
American pipit	5	4	103
White-rumped shrike	10	8	65
Audubon warbler	18	8	59
Bobolink	4	1	1
Western meadow lark	66	38	172
Red-wing blackbird	3	3	76
Brewer blackbird	12	11	139
Bullock oriole	2	2	12
Black-headed grosbeak	1	1	3
Western vesper sparrow	6	6	105
Western lark sparrow	4	1	89
Sage sparrow	8	3	46
Western chipping sparrow	8	8	288
Gambel sparrow	2	2	126
Total	387	225	2373

Recognizable pentatomid material in the stomachs of the 33 species of birds here listed included 38 *Brachymena* including 14 *B. sulcata* Van D. in 6 stomachs, 2 *B. tenebrosa* Walk. and 5 *B. 4-pustulata* (Fabr.); 40 *Chlorochroa sayi* Stal in 22 stomachs, 15 *C. uhleri* Stal in 11 stomachs, and 2 *C. ligata* (Say) 26 *Thyanta custator* (Fabr.) in 19 stomachs, 1 *Peribalus abbreviatus* (Uhl.); 4 *Euschistus inflatus* Van D. in 3 stomachs and 5 *E. variolarius* (P.B.) in 4; 3 *Acrosternum hilaris* (Say); and 2 *Carpocoris remotus* Horv. One nymphal pentatomid was recognized in a stomach of a violet-green swallow, one in

a rock wren and one in a Mountain bluebird. Also 138 pentatomid eggs were found in Arkansas kingbird stomachs, 13 in longtailed chicadees and 46 in rock wren stomachs. This makes a total of 384 adult and 3 nymphal pentatomids found still to be in recognizable condition in 225 of the 2373 stomachs, of the 33 species of birds found to contain this material. In addition, 197 pentatomid eggs also were found.

Snipe Flies in Utah

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Snipe flies, *Symphoromyia hirta* Johnson, (det. C. T. Greene), were abundant at the Monte Cristo U. S. Forest Camp and in nearby areas of the Cache National Forest on top of the Wasatch Mountain range, at an elevation of about 9600 feet, on July 24, 1943. These flies became decreasingly abundant at lower elevations toward the east, down Allen Canyon, and southwest, along the road to Ogden. The most interesting and conspicuous behavior noted was the great abundance of these flies on and around one of the two-foot high cast-iron water hydrants, standing in a sunny cleared spot. A rock base and a wet area surrounded each hydrant. On one of these hydrants approximately 350 *S. hirta* rested, while an estimated 2000 flies or more swarmed around the warm metal hydrant in a column which usually varied from three to three and one-half feet in diameter and extended from a few inches above the ground to 6 or 8 inches above the hydrant. After watching this performance for some minutes one of the writers attempted to fill two thermos bottles at this hydrant; a hasty retreat proved the better part of valor. Arming themselves with insect nets, the writers beat off the pursuing horde and attacked those still swarming around the tap. In one minute of collecting, more than one-half pint of these vicious blood-sucking flies were taken. The attacking flies still were so abundant that the collectors were forced to enter a closed car for protection. A few minutes later more than 200 additional *S. hirta* were collected around the hydrant by one writer while the other quickly filled the thermos bottles. Again retreat into the car was desirable. A second camp site nearby was examined. In this case the hydrant was partially shaded by trees. *S. hirta* were numerous here but not present in the excessive numbers encountered at the first stop.

Upon returning approximately 15 minutes later the flies were found to have resumed their hovering flight around the first hydrant, their numbers having been increased by other flies moving in, until the number present appeared to be approximately 60 per cent as great as when first observed. This swarming activity appeared to be carried on by a population of *S. hirta* only. None of the moderately abundant *Symphoromyia atripes* Bigot in this same area were noticed to join in this flight actively, although *atripes* attacked the writers with equal readiness, wherever they were encountered.

S. hirta has been taken in various parts of Utah, at times being abundant, especially during July and the first half of August. Knowlton and F. C. Harmston collected specimens in Provo Canyon, Utah, June 27, 1939. Harmston took specimens at Fort Duchesne, August 12, 1935. During July this species has been collected in Utah at Card Canyon, Garden City, Hurricane Logan Canyon, Miner's Basin and Wilson Mesa in the LaSal Mountains, Mt. Timpanogos, Provo and Weber Canyon. Most of the specimens were taken after they had bitten the collector, at a time when snipe flies were abundant and annoying. During early August, this species has been collected at Logan and in Logan Canyon.

Symphoromyia atripes Bigot (det. C. T. Greene) also were present at Monte Cristo and nearby parts of the Cache National Forest in the Wasatch Mountain range on July 24, 1943, but was much less abundant than *S. hirta*. However *S. atripes* was more abundant that day at lower elevations, including Allen Canyon, Garden City, Card Canyon Ranger Station in Logan Canyon, at which place they were especially numerous and readily attacked persons in the area. Knowlton and W. P. Nye were annoyed by the bites of this species at Card Canyon on July 24, 1938 and again on July 9, 1939.

Simuliidae were observed swarming around the heads of four hobbled sheep-camp horses, on the highway about one mile southwest from Monte Cristo, on August 24, 1943. Besides the hundreds of swarming buffalo gnats, from 15 to 35 were present in each ear examined. In addition, dozens of feeding females were present on head, neck, shoulders, back, front legs, on the brisket and under the belly. Many of the simuliids had abdomens engorged with blood; such females were seen to stop feeding, crawl to the outer hairs and fly away. Blood would sometimes spurt from the bodies of the engorged individuals, captured with forceps. Of 83 individuals collected and preserved in alcohol, 77 proved to be *Simulium arcticum* Mall. and 6 were *S. vittatum* Zett. (det. Dr. A. Stone). In addition to Simuliidae, about 15 to 25 snipe flies, approximately 90 per cent of them *S. hirta* and the rest *S. atripes*, were attacking each of the horses. The horses showed definite signs of annoyance due to the blood sucking flies. The gentlest horse apparently welcomed the attention of the writers, which temporarily eased the attack from the viciously biting flies.—12-20-43.

Husk Characters of Field Corn in Relation to Feeding by Birds on Earworms

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Studies of the factors that contribute to protection of field corn ears against damage by earworms, *Heliothis armigera* (Hbn.), have shown that birds sometimes remove a sufficient number of larvae to interfere with a true evaluation of strains in comparative tests. This interference frequently occurs in strains that have short, tight husks, a condition that exposes the larvae so that they are readily accessible to predators. Sometimes the birds also cause incidental damage by feeding on the kernels of ears from which they have removed larvae.

An instance of this type of feeding by birds on earworms in Cuban Yellow Flint corn was observed at Sanford, Fla., in June 1940. In this variety the husk leaves are very tough, cling tightly about the kernels, and compress the interior silk mass so closely that larvae are able to enter the ears only by eating a channel through it. An unusually large number of larvae were observed crawling over the plants, a habit that has been observed to be associated with competition arising when 5 to 10 larvae occur per

ear or when they have been disturbed by predators, and individuals of the fourth to sixth instars were feeding partially exposed in the silks at the tips of the ears. Despite the abundance of larvae, many ears whose silks had been eaten contained none. From these ears larvae had been taken by birds, which could readily observe and reach them in their exposed feeding locations, besides taking those that were crawling about. In this field birds, such as warblers, whose beaks are not suitable for puncturing or shredding the husks, could reach and consume a large proportion of the earworm population. Observations of bird feeding in many cornfields have shown that such birds seldom reach larvae that have penetrated into ears having long or loose husks. Many ears in this field received no injury to the kernels despite an abundant earworm population, because the larvae could not penetrate into the silk mass and gain protection from their bird enemies.

Table 1.—Effectiveness of birds in limiting damage by earworms in ears varying in husk extension, shown by a summary of the average class index of damage of infested ears in all possible single-cross combinations of six inbred lines.

	Average Class Index of Damage in Single Crosses of Parent Inbred Lines						
Husk extension in inches	Ill. Hy		Tenn. J8-6G	CI.2	Kan. Kys	CI.7	Average
0	2.1	2.0	1.7	2.0	2.0	1.8	1.9
0.5	2.2	2.3	2.1	2.2	2.4	2.1	2.2
1.0	2.3	2.5	2.2	2.1	2.5	2.2	2.3
1.5	2.3	2.4	2.1	2.1	2.4	2.2	2.2
2.0	2.4	2.2	2.3	2.2	2.5	2.3	2.3
2.5	2.5	2.5	2.2	2.2	2.5	2.1	2.3
3.0	1.8	2.2	2.4	2.2	2.5	2.5	2.2
Means	2.2	2.3	2.1	2.1	2.4	2.2	2.2
Percentage of ears with 0 and 0.5-inch husk extension	36.4	33.7	48.3	11.2	23.3	36.3	32.4

In an experiment conducted in Fairfax County, Va., in 1941, involving all possible single-cross combinations of 6 inbred lines of field corn, data were obtained on the relation of husk extension to the frequency of removal of larvae from the ears by birds. Each single cross was replicated 4 times in randomized blocks. The ears were examined 30 days after the 50 per cent silking date of each plot. It was observed that the larval population at this stage of development had receded to approximately 30 per cent of that present in a duplicate block in which the examination of ears was made 15 days after the emergence of silks. At the time of the 30-day examination a high percentage of the remaining larvae were in the fifth or sixth instar.

That the reduction was largely caused by birds was shown by actual observations of their activities in the plots and the characteristic appearance of the ears from which larvae had been removed. This consisted of shredding or splitting of ears having husk extensions and incidental feeding by the birds on the kernels at the tip of the cob, or, in the case of ears with short husks, feeding by larvae in the fifth or sixth instar that had not matured but were missing from the ears. The species that was observed to be involved especially was the red-winged blackbird, *Agelaius phoeniceus phoeniceus* L. These birds visited the field singly in July. They seemed to prefer to feed on earworms in the fifth or sixth instar, as at this time they were getting food for their young.

The effect of the variation in husk extension on removal of larvae by birds is shown in table 1, where the damage inflicted by earworms in the single crosses containing the respective parent inbred lines is classified according to the husk extension. The index of injury depended upon the number of damaged kernels per ear. Class 1 contained from 1 to 5 kernels; classes 2 through 5, damage at intervals of 10 kernels.

With the exception of the 3-inch extension of Ill. Hy crosses, the lowest rate of damage by earworms in all the parent lines was in the ears having no husk extension. The Tenn. J8-6G crosses had the highest percentage of ears with practically no husk extension and the lowest rate of damage in such ears. This line has a short, tight husk fitting closely over the tip of the ear, and contributes to these characters in crosses. When the removal of larvae by birds is not a factor, the normal trend in filled ears is for the damage to decrease with longer husk extensions.

The percentages of larvae removed from infested ears, classified according to the extension of the husk for ½-inch increases in length, are given in table 2. It is seen that as the husk extensions increased, the percentages decreased.

Table 2.—Relation of the husk extension of field corn to the frequency of removal of earworms by birds. Gunston Cove, Va., 1941.

Husk Extension Inches	Ears Observed	Ears with Larvae Removed
0	269	45.0%
0.5	484	26.2
1.0	700	20.1
1.5	364	12.3
2.0	395	7.6
2.5	134	2.5
3.0	42	2.4
Total	2388	19.6

These observations indicate that birds may contribute to a considerable extent in limiting damage by earworms in field-corn ears having short, tight husks. Owing to their inability to penetrate into such ears quickly, a larger proportion of the larvae are found and eaten by birds than in the case of ears having longer or looser husks which they can penetrate more rapidly or deeply.—11-19-43.

Performance of Dichlorodiphenyl Trichloroethane (DDT) Used Against the Oriental Fruit Moth

Byrley F. Driggers, *New Jersey Agricultural Experiment Station, New Brunswick*

During the summer of 1943 the writer had an opportunity to determine the effectiveness of dichlorodiphenyl trichloroethane, DDT, or *Gesarol*, in preventing fruit infestation by the third brood of larvae of the Oriental fruit moth on several varieties of peaches. During the early summer of 1943 arrangements were made with Messrs. C. H. Hadley and

Table 1. Per cent fruit injured by Oriental fruit moth on unsprayed check trees and trees sprayed once with DDT one pound to 100 gallons of water.

TREE NO.	VARIETY	TREATMENT	NO. FRUITS EXAMINED	VISIBLE INJURY	INVISIBLE INJURY
				%	%
1	Raritan Rose	South Check	400	20.3	32.0
2	Raritan Rose	1 lb. DDT	500	3.8	10.0
3	Raritan Rose	North Check	(Tree) Missing)	—	—
4	Raritan Rose	South Check	350	15.4	21.0
5	Raritan Rose	1 lb. DDT	350	6.6	4.0
6	Raritan Rose	North Check	300	12.7	16.0
7	Cumberland	South Check	400	28.0	31.0
8	Cumberland	1 lb. DDT	350	6.5	2.0
9	Cumberland	North Check	450	23.3	24.0
10	Cumberland	South Check	350	35.1	35.0
11	Cumberland	1 lb. DDT	350	7.7	4.0
12	Cumberland	North Check	350	27.7	22.0
13	Triogem	South Check	200	46.0	60.0
14	Triogem	1 lb. DDT	300	5.3	4.0
15	Triogem	North Check	200	50.2	42.0
16	Triogem	South Check	250	52.4	38.0
17	Triogem	1 lb. DDT	250	13.2	16.0
18	Triogem	North Check	250	56.0	42.0
19	Golden East	South Check	250	34.4	52.0
20	Golden East	1 lb. DDT	250	11.6	28.0
21	Golden East	North Check	250	42.0	44.0
22	Golden East	South Check	300	38.0	60.0
23	Golden East	1 lb. DDT	150	15.2	28.0
24	Golden East	North Check	250	44.8	48.0

Walter E. Fleming of the Japanese Beetle Laboratory, Bureau of Entomology and Plant Quarantine, to block test several promising spray materials in comparison with derris as a control for the Japanese beetle on peaches in the writer's orchard in Middlesex County in central New Jersey. Details concerning the method of preparation of the DDT, the time of application and the effect on Japanese beetles will be published.

The orchard where the experiments were run consisted of a five-year-old block of peaches made up of the varieties Triogem, Sunhigh, Golden East, Elberta and J. H. Hale. An adjoining block of four-year-old trees was made up of the varieties Summer Crest, Red Rose, Golden Globe, Cumberland and Raritan Rose. All of these varieties had a satisfactory set of fruit in 1943.

Each of the varieties listed consisted of one row of from 40 to 50 trees each. The experimental set-up consisted of one row plots running across the ten varieties with every other row left unsprayed. Each treatment was run in duplicate. With this arrangement each variety had two trees sprayed with each spray combination being tested with two unsprayed check trees on either side of each sprayed tree.

At the time the plots were laid out and the sprays applied no thought was given to the problem of Oriental fruit moth control. It so happened, however, that the first spray application was made on July 14 at the beginning of third brood Oriental fruit moth larval entry. A further fortunate circumstance (from the experimental standpoint) was the prospect that third brood Oriental fruit moth larvae injury would be unusually severe. (Weekly surveys of twig feeding first and second brood larval parasitism in this orchard in 1942 had shown 57 per cent of the larvae parasitized; a similar survey in 1943 showed only 13 per cent of first and second brood larvae parasitized.)

All the fruit on two trees of each of the early ripening varieties Raritan Rose and Cumberland and the midseason ripening varieties of Triogem and Golden East, which had been sprayed on July 14 with 1 pound of DDT to 100 gallons of water, was examined for Oriental fruit moth injury between August 6 and August 21. Similarly, all the fruit on two unsprayed check trees, one to the north and one to the south of each sprayed tree, was examined. In this manner the percentage visible injury was determined. To determine the invisible injury part (usually 25 per cent) of the apparently sound fruit was cut and the pits removed. The results are set forth in table 1.

The data in table 1 show a marked reduction in Oriental fruit moth injury to fruit on trees sprayed once with DDT one pound to 100 gallons when compared to adjoining unsprayed trees. The treatment apparently was effective over a period of 3 to 4 weeks since the reduction in worm injury was greater on the varieties harvested first. It is interesting to note that the worm injury, particularly the invisible injury, was less on the check trees to the north than on the check trees to the south of the sprayed trees. At the time the sprays were applied the wind was from the south. The spray drift on the north checks appeared to give some reduction in larval injury on those trees as compared to the check trees to the south. No injury to the fruit or foliage was observed from the one spray application of DDT.

Toxicity of DDT to *Blattella germanica*, as Compared with Sodium Fluoride, Derris and Pyrethrum

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Dichlorodiphenyl trichloroethane, $(C_6H_4Cl)_2CHCCl_3$, has attracted wide attention among entomologists and chemists, as a possible substitute for many of our present insecticides, some of which are, due to war conditions, either scarce or entirely unavailable for civilian use. Although this compound has been known to chemists for over seventy years, its insecticidal properties were only recently discovered in Switzerland, as described in two English patents (Nos. 547,871 and 547,874) 9142 and in one U. S. patent (No. 2,329,074) 1943 issued to J. R. Geigy Company operating in the U. S. and Switzerland. While its chemical formula corresponds to 2,2,-parachloro-phenyl-1,1,1-trichloroethane, it has become known commercially as *Gesarol*, *Neocid* and DDT.

During the summer months of 1943, the writer has tested DDT against several species of sucking and chewing insects. This brief report presents results from laboratory tests on the German roach, *Blattella germanica*, in which the toxicity of DDT was compared with sodium fluoride, finely ground powders of derris root, and pyrethrum flowers.

MATERIALS AND METHODS.—The insecticides were tested as dusts, the base of which was a mixture of 50 per cent talc and 50 per cent soybean flour. Various concentrations of the four insecticides were incorporated in this base-mixture. Sodium fluoride and DDT were chemically pure; the derris contained 5 per cent rotenone, and the pyrethrum analyzed about 1 per cent pyrethrins.

The tests were conducted by the following method. The insides of one-gallon glass jars, of uniform size, were dusted with the insecticide mixtures so as to thoroughly cover the bottom and inner walls. The excess dust was then shaken out, allowing only as much dust to remain as could adhere to the glass. Preliminary determinations have shown that approximately 140 mgm. of dust was required to cover one jar. Since the inner surface area of each jar was approximately 178 sq. in., the average amount of dust deposited by this method was about 0.8 mgm. per sq. in.

From 20 to 30 adult roaches, 10 weeks old, were transferred to each jar and, supplying them with water, were kept under observation for 48 hours. The main object was to determine the minimum concentration of DDT necessary to kill 100 per cent within a comparatively short period, as compared with the other three insecticides. Duplicate jars were used for each test.

The data presented in table 1 show that 7 per cent DDT and 33 per cent sodium fluoride were the minimum concentrations required under the described laboratory conditions, to kill 100 per cent roaches within 48 hours. DDT appears, therefore, to be about 5 times as toxic to roaches as is sodium fluoride. Dusts containing either 33 per cent derris or 33 per cent pyrethrum gave, within the same period, only 30 per cent and 90 per cent kill respectively.

In general, the results from these preliminary tests indicate that DDT is vastly more toxic to roaches than are sodium fluoride, derris or pyrethrum.

Table 1.—Toxicity of DDT to roaches as compared with sodium fluoride, derris and pyrethrum.

% Toxic Ingredient in Mixture	Approximate % Toxic Ingredient per Sq. In. of Surface	Total Roaches Tested	Average % Dead After	
			24 Hours	48 Hours
	mgm.			
1 DDT	0.008 DDT	44	21	36
2 DDT	0.016 DDT	53	32	63
4 DDT	0.032 DDT	51	42	70
7 DDT	0.056 DDT	61	80	100
10 DDT	0.080 DDT	47	90	100
10 NaF	0.08 NaF	62	52	82
20 NaF	0.160 NaF	42	50	95
33 NaF	0.264 NaF	44	85	100
10 Derris	0.080 Derris	46	—	18
33 Derris	0.264 Derris	47	22	30
10 Pyrethrum	0.080 Pyrethrum	45	—	66
33 Pyrethrum	0.264 Pyrethrum	40	70	90
Check None (Base Mixture)	None	51	2	6

Laboratory Tests on the Oriental Fruit Moth with Special Reference to DDT

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The oriental fruit moth, *Grapholitha molesta* (Busck), was first found established in California during the late summer of 1942. Subsequent survey work has shown its spread into most of the extensive peach-growing areas of the state and it now threatens to become the most important pest of peaches in this area.

As a part of the effort being expended to devise a control which is practical and suited to the culture of peaches, studies have been undertaken on the possible use of dust and spray treatments. Initial emphasis has been placed on laboratory tests directed against the newly-hatched fruit moth larvae. Over 150 different treatments have been evaluated in making individual tests on over 12,000 larvae.

Additional studies have been made to determine the effect of spray or dust deposits on fruit moth adults.

While these studies are as yet preliminary in scope, the remarkable results obtained with several of the test materials prompts a note at this time. The toxic principle of these materials is the synthetic organic compound, 2,2-bis (parachlorophenyl) 1,1,1-trichloroethane. By general acceptance the abbreviation DDT is now used to designate this compound, DDT deriving from the first letters of a descriptive name for the compound, namely, dichloro diphenyl trichloroethane. The samples of DDT used in these tests were supplied by Doctor V. Froelicher of The Geigy Company, Inc., New York, and parenthetical references relate to their codes for the various samples.

DDT in all the forms tested has been highly toxic to the newly-hatched fruit moth larvae. The most satisfactory method of evaluating the toxicity of deposits to the larvae has consisted of fastening glass rings to the dusted or sprayed surface of apples and confining a single egg in the blackhead stage in each cell thus formed. The ring is secured to the apple with a 50–50 mixture of beeswax and paraffin and a narrow band of wax is applied with a dropping pipette around the inside of the ring where it touches the fruit so as to prevent the larvae from escaping or from entering the fruit at points where the deposit might have been disturbed by virtue of contact with the ring. Cut from glass tubing 1 inch in diameter, the rings are approximately a half-inch in length and lend themselves readily to manipulation and can be used again after being thoroughly cleaned. Eggs which have been deposited on sheets of wax paper are transferred on small pieces of the paper to the individual cells and fastened to the inside of the glass ring with melted wax. To enclose the test cell, a small square of longcloth is sealed to the top of the glass ring.

Six cells are affixed to the equator of each fruit and five fruits are used in each test. A minimum of three tests are made in the evaluation of each treatment. Using this method an average of between 85 and 90 per cent of the larvae enter untreated fruits.

In contrast, deposits of DDT on fruits prevent the entry of large numbers of the newly-hatched larvae. A mixture containing 25 per cent recrystallized DDT (*GNB-A* 25 per cent pulverized) which has been slurried with a small amount of wetting agent (*Triton NE*) and an amount of a carrier (*Pyrax ABB*) to bring the total of solids up to 4 pounds per 100 gallons of spray, has given efficiencies of 67, 76 and 92 per cent when used at the rates of 4, 8 and 16 ounces, respectively, of actual compound. Recrystallized DDT (*GNB-A* 100 per cent) prepared in the same manner gave efficiencies of 39, 59 and 87 per cent when used at the rates of 4, 8 and 16 ounches, respectively, of actual compound. In all cases where higher dosages of DDT were used, none of the larvae succeeded in entering the fruits. The use of wetting agents in the customary amounts generally decreased the effectiveness of the spray. In comparable tests basic lead arsenate used at the rate of 3 pounds per 100 gallons was only 9 per cent efficient in preventing entries.

Additional tests against the newly-hatched larvae in which the evaluation of treatments is not completed indicate that DDT is highly effective when dissolved in oil and other organic solvents or when prepared in dust mixtures. In the tests with dust deposits none of the larvae has succeeded in entering the fruits.

In view of the unusual toxicity of DDT and its properties as a contact poison, a series of tests have been made to determine the effect of the material on adult fruit moths.

Small potted peach seedlings were sprayed with DDT and 3 days later each placed in a screen cage with 10 newly-emerged moths. The moths were seldom observed to come in contact with the plants but at the end of 72 hours an average of 69 per cent of the moths were dead or obviously incapacitated when confined with plants sprayed with DDT (*GNB-A* 25 per cent pulverized) at the rate of 1 pound of actual compound. All but 7 per cent of the moths were alive in cages containing unsprayed plants.

In other tests the cages themselves were sprayed with the 1 pound concentration of DDT or dusted with a mixture containing 3 per cent DDT (*Gesarol A Dust*). Ten newly-emerged moths were placed in each cage. At the end of 24 hours, 72 per cent of the moths in the sprayed cages were dead or incapacitated while 83 per cent of the moths in the dusted cages were similarly affected. All of the moths in the treated cages were dead in 48 hours. Mortality in untreated cages amounted to 3 per cent in the same period.

These preliminary studies in the laboratory have indicated that dichloro diphenyl trichloroethane is highly toxic to the newly-hatched larvae and the adults of the oriental fruit moth. Further work is in progress to determine its effectiveness against all vulnerable stages of this insect when used in several forms and with various supplements. These studies will be followed by extensive field tests.—2-10-44.

Results with Dichloro-diphenyl-Trichloroethane in Control of the California Red Scale

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Extensive laboratory and limited field tests have shown dichloro-diphenyl-trichloroethane or, more specifically, 2,2-bis (parachlorophenyl) 1,1,1-trichloroethane, to offer promise in the control of the California red scale, *Aonidiella aurantii* (Mask.). This chemical has been previously referred to as Gesarol, DDT and GNB-A (Boyce, 1943). For convenience it appears preferable at present to refer to it locally as GNB-A, realizing that GNB-A and DDT are designations for the same compound.

Laboratory tests with GNB-A in solution in kerosene and in other grades of petroleum spray oils, applied as oil-water emulsions, have not only resulted in an increased kill of adult females and younger stages of red scale over that of the oils alone, but have been strikingly effective in preventing young scale crawlers from settling and developing on citrus fruits for a period as long as 60 days after spraying, when the fruits were discarded because of breakdown. Tests now in progress indicate the period of effectiveness of the residue may greatly exceed 60 days. Typical data are presented in table 1.

It is evident from table 1 that the kill of red scale was increased by increasing the concentration of GNB-A and that, although hundreds of young were produced per fruit, in the tests with the two higher concentrations of GNB-A, only one insect per fruit survived and developed.

Table 1.—Effect of GNB-A in light-medium grade emulsive petroleum spray oil on red scale mortality in laboratory tests.

Treatment (Oil-Water Emulsions)	Percentage Kill of Adult Females	Effect of Residue on Young that Were Born after Treatment
0.75 per cent oil	26.3	1050 young settled and developed per fruit
0.75 per cent oil containing 2 grams GNB-A per 100 cc oil	34.8	60 young settled and developed per fruit
0.75 per cent oil containing 4 grams GNB-A per 100 cc oil	44.1	No young settled and developed per fruit
0.75 per cent oil containing 6 grams GNB-A per 100 cc oil	56.4	1 young settled and developed per fruit

Emulsions of xylene or benzene containing GNB-A have had little effect on the kill of adult female red scales, but the residue has inhibited the settling and development of the young for at least 45 days. Deposits resulting from suspensions in water of technical grade GNB-A, used at the rate of 2 pounds to 100 gallons, inhibited more than 95 per cent of the young crawlers from developing on citrus fruits.

In all laboratory tests the effect of the residue of GNB-A on the young appeared to be about as pronounced at the end of the experiment (terminated due to fruit breakdown) as at the beginning.

In many of the experiments with GNB-A oil sprays, the young crawlers were killed before they emerged from beneath the waxy covering of the mother insects. These dead young scales block the aperture for exit where they pile up and become so packed that, as the mother scale continues to produce more young, the waxy covering is pushed up in the form of a ridge at the tip of the pygidium of the insect.

It is interesting to note that on treated fruits having a very light deposit of GNB-A, which did not kill the young scales that were born subsequent to treatment, the development of the insects progressed at a much slower rate than on the control fruits.

Tests have been conducted in which powdered cube root and also derris extractives were each incorporated in kerosene and other light grades of petroleum spray oils containing GNB-A. This was done in order to evaluate the combined effectiveness of the high initial kill of adult females afforded by the rotenone and rotenoids and the prolonged residual effect of the GNB-A in preventing the young crawlers, produced by the females that survive, from settling and developing. The results obtained were very promising. As these materials were used, they appear to be compatible.

In the laboratory studies now in progress, GNB-A is being used in many ways, such as with various solvents, oils, wetting and adhesive agents and also in combination with other toxicants, in an attempt to determine the most effective manner of use of the material in control of the red scale.

Field experiments are being conducted by Dr. Walter Ebeling, of this Station, in which GNB-A is being used in a number of ways. Fifty days after treatment, orange and lemon fruits were picked from certain plots that had been sprayed with light-medium grade petroleum spray oil and also with kerosene, each of which contained GNB-A. These fruits were brought into the laboratory and infested with young red scale crawlers. In the interim between spraying and picking the fruits, there were several rainstorms which resulted in a total of about 7 inches of rainfall. While from 80 to 90 per cent of the young scale insects settled and developed on the check fruits, which were treated with light-medium oil or kerosene alone, only from 5 to 15 per cent settled and developed on the fruits treated with these same oils containing GNB-A.

No plant injury has been observed to date from any applications of GNB-A.

The cooperation of Dr. R. C. Roark of the United States Department of Agriculture, Dr. W. C. O'Kane and Dr. G. R. Ferguson of the Crop Protection Institute, and Dr. V. Froelicher of the Geigy Company in supplying materials for these studies is greatly appreciated.—1-31-44.

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Lt. (j.g.) Harold R. Yust

Mrs. Yust writes of her husband that he was given a commission on June 21 and was stationed first at Bethesda, Maryland and in Florida and was sent overseas on September 2. He has been doing Malaria Research work in the Pacific Area since the time, finding the work interesting and, up to the present, enjoying good health.

Harvey B. Morlan

Mr. Morlan received a commission as Assistant Sanitarian in the United States Public Health Service on July 29, 1943. To date his headquarters have been in the City Health Department of Galveston, Tex.

Tests Conducted by the Bureau of Entomology and Plant Quarantine to Appraise the Usefulness of DDT as an Insecticide

P. N. ANNAND *Chief*, and Members of the Staff, *U. S. D. A., Agr. Res. Adm. Bureau of Entomology and Plant Quarantine.*

Introductory Discussion of DDT

P. N. ANNAND

In the effort to find new insecticides for the protection of man and animals from attack by annoying and disease-bearing insects and to control species which destroy food and fiber, the Bureau of Entomology and Plant Quarantine is testing many different materials. The materials tested include those developed as a result of research by the Bureau, as well as some obtained from other sources, including those supplied by industry. The urgent need to locate substances that might be used as substitutes or alternates for insecticides the available quantities of which are insufficient to meet the needs has made it desirable to test many materials that are covered by private patents or protected by trade-mark names.

One of the proprietary compounds that has been tested during recent months is a synthetic organic chemical, 2,2-bis(parachlorophenyl)1,1,1-trichloroethane. For convenience, the designation "DDT" has been adopted, being derived from the generic name "dichloro-diphenyl-trichloroethane."

This chemical was first prepared by Zeidler (1874) by allowing anhydrous chloral and chlorobenzene to react in the presence of concentrated sulfuric acid. Chemically pure DDT is a crystalline solid, practically colorless, almost odorless, and rather stable. It is insoluble in water but soluble in most organic solvents, and it has low volatility.

Its possible insecticidal usefulness was first made public about four years ago through the researches of Paul Müller in Switzerland, who reported its effect on flies, moths, and plant lice. The insecticidal use of this material is covered by a number of patents, all of which are assigned to J. R. Geigy A. G. Basel, Switzerland. The initial application for a patent was filed in Switzerland on March 7, 1940. Two British patents, 547,871 and 547,874, were issued to Rosling Morgan Hughes under date of September 15, 1942. The most recent patent is United States Patent 2,329,074, entitled "Devitalizing Composition of Matter," issued to Paul Müller under date of September 7, 1943.

It is understood that in Switzerland the material is available for agricultural uses under two trade names, *Gesarol Spray Insecticide* and *Gesarol Dust Insecticide*, and that the former contains 5 per cent of DDT in a diluent, wetter, and sticker, and that the dust mixture contains 3 per cent of DDT. A product containing 5 per cent of DDT for use against human lice is also marketed in Switzerland under the trade name *Neocid*.

Prior to the adoption of the symbol DDT to designate the active ingredient, a technical grade of the material manufactured in Switzerland was referred to as *GNB*, and a technical grade of the material manufactured in the United States as *GNB-A*.

Several articles dealing with the use of this chemical against agricultural pests have been published in Switzerland and Germany (Wiesmann, 1942a–c). Wiesmann (1942 b and d) also published the results of some experimental work with honey bees, and more recently a paper in a Berlin journal (1943) showing the effectiveness of the material as a residual fly spray. The insecticidal possibilities of this material have also been noted in various publications in the United States (Anonymous, 1943a–c).

The reaction of certain insects to DDT indicates that it is a nerve poison. The experimental work on its toxicity to higher animals indicates that there, also, it acts primarily as a nerve poison. It is distinctly toxic when ingested or dissolved in a solvent, such as oil, which can be absorbed through the skin. Its toxicity has not been fully explored. Preliminary data suggest, however, that the toxicity of the material as it may be applied to control at least certain pests is of an order that may make its use as safe as some of the insecticides now employed. In any experimental use as an insecticide its low solubility, low volatility, and stability should be kept in mind. Experimental work in the Bureau indicates that the loss of DDT by evaporation from spray deposits will occur too slowly to decrease its effectiveness appreciably.

At present DDT is under allocation by the War Production Board, and the supplies available are not adequate to provide for general or civilian use.

Preliminary tests suggest that DDT is one of the more promising synthetic organics that might be used to control insects. Informal comments that have been made concerning it and references in available foreign literature have aroused rather wide and general interest, and there has been considerable informal discussion as to its possible usefulness. This wide interest and the desire for information on results of the tests stimulated by insecticide shortages point to the desirability of deviating from the practice usually followed in reference to reports on proprietary materials and to make public the results of some of the preliminary experimental work that has been done.

The following articles report some of the experimental work with DDT, largely as an agricultural insecticide, that has been carried out by employees of the Bureau of Entomology and Plant Quarantine during the short time that the material has been under experimentation. The work reported from the Orlando, Fla., laboratory was done for the armed forces under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.—12-1-43.

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DDT for the Control of Human Lice[1]

R. C. BUSHLAND,[2] L. C. MCALISTER, JR., G. W. EDDY, and HOWARD A. JONES

In December 1942 DDT was tested against the body louse, *Pediculus humanus corporis* Deg., The first sample, a commercial dust, proved far more promising in preliminary tests than any of the hundreds of synthetic organic compounds previously tested. Numerous tests were also made with various dilutions of the commercial dust and with small amounts of the crystalline material extracted from the commercial dust. Later tests with pure DDT synthesized by H. L. Haller of the Bureau and with other commercial samples confirmed the initial observations that DDT was a highly effective lousicide. The present report shows the value of DDT for the control of the body louse, and also of the head louse, *P. humanus humanus* L., and the crab or pubic louse, *Phthirus pubis* (L.).

The research on the development of DDT for the control of human lice followed three major lines—use in powder form, impregnation in garments, and use in a liquid preparation for application to the head and body. Recommendations for all these treatments have been made to the armed forces through the office of Scientific Research and Development.

[1] Work done at the Orlando, Fla., laboratory. Acknowledgment is gratefully made of assistance given by E. F. Knipling, who not only directed the work but actively participated in it. The authors were also assisted by G. H. Culpepper, D. Burnett, Jr., and Anola B. Hendrick.

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DDT IN A LOUSE POWDER.—In testing powders for the control of the body louse, the "arm and leg" method was used. The inner surface of cloth sleeves was treated with the powder, and the sleeves were placed on the arms and legs of research subjects. Each garment was infested with 25 young adult lice, and the insects were confined by fastening the sleeves with tape. Examinations were made at intervals of 24 and 48 hours, and when the treatment was effective the garment was reinfested to determine the duration of protection. Effective materials were further evaluated by tests on grossly infested subjects with whole suits of underwear. The subjects were heavily infested with lice and eggs from the laboratory colony. They then put on the treated underwear and wore it day and night, sleeping in it under camp conditions. Periodic counts of lice were made, and infestations were repeated to determine the duration of effectiveness of the treatment.

By these methods the DDT powder recommended to the armed forces has been found highly effective and longer lasting than any other louse treatment known to be in use. This powder is more effective than the MYL powder previously recommended by this Bureau. The outstanding feature of DDT is its long-lasting quality.

From the results obtained it appears that on grossly infested subjects the approved percentage of DDT powder will provide almost complete protection for 3 weeks, and give effective control for a longer period. DDT has no ovicidal properties, but the duration of effectiveness extends beyond the normal range for incubation of body louse eggs. It has been found to be equally effective in any one of a number of diluents. DDT applied as a powder is also very effective in destroying head lice and crab lice.

DDT IMPREGNATED IN GARMENTS.—Certain lousicides have been found to remain effective much longer when impregnated in garments than when used in powder form. This is true of DDT. The most remarkable feature of DDT-impregnated clothing, however, is that the treatment kills lice even after the garments have been laundered several times. Tests of garments impregnated with DDT have been made both by the arm and leg method and on grossly infested subjects. Impregnation has been accomplished by dipping the clothing in solutions of DDT in a volatile solvent or an aqueous emulsion, with no difference in effectiveness. Cotton and wool garments can be impregnated by either method with no significant difference in results.

In tests on grossly infested subjects two-piece, 50 per cent wool underwear impregnated with a solution of DDT when not washed remained effective for 3 to 5 weeks' wearing, while similar suits when washed once a week were effective for 2 to 3 weeks. Suits impregnated with a higher percentage of DDT, when washed once a week, remained completely effective through five washings and were still moderately effective after six washings. With a still larger percentage of DDT garments gave complete control of lice after nine washings and 9 weeks' wearing. In more recent tests suits dipped in a DDT solution of intermediate strength were effective through six to eight washings, and this strength has been recommended for use by the armed forces. Methods for large-scale treatment of garments have been developed.

LIQUID PREPARATIONS OF DDT.—Various types of liquid preparations, including solutions and emulsions, have been tested for application as sprays or

by other means. The object was to develop a preparation that would be useful for body, head, and crab lice and would destroy all stages of lice with one treatment, and at the same time provide residual action against possible reinfestations. The lowest concentration that would be effective when applied as a spray to the entire body has been recommended for use by the armed forces. This liquid preparation is being used as an auxiliary treatment in the complete delousing process. In this form it is particularly useful for the control of head and crab lice.

DDT as a Residual Spray for the Control of Bedbugs[1]

A. H. MADDEN, ARTHUR W. LINDQUIST, and E. F. KNIPLING[2]

A large percentage of the bedbugs in an infested building remain concealed and protected when sprays are being applied. The degree of control obtained must therefore depend to a large extent upon the toxicity of the resulting deposit on walls, floor, and beds, with which the bugs come in contact when they leave their hiding places. Furthermore, the residue must retain its toxicity for an extended period to prevent early reinfestation through the hatching of eggs or introduction of additional bugs.

An investigation was conducted at Orlando, Fla., beginning in September 1942, for the purpose of finding a material with persistent insecticidal qualities. Approximately 1,500 laboratory tests with about 100 materials were completed, and DDT, first tested in January 1943, was found to be the most outstanding, with pyrethrum somewhat less effective. The results obtained to date with DDT under both laboratory and practical conditions are given here. A few results with pyrethrum also are given for comparison. The tests were conducted against a mixed population of the common bedbug, *Cimex lectularius* L., and the tropical bedbug, *C. hemipterus* F., but no difference in resistance was detected between the two species.

JAR TESTS.—In initial laboratory tests circular woolen pads of the same diameter as the inside of a half-pint fruit jar were sprayed or dusted on both sides with the test material, 0.25 milliliter of liquid or 0.8 gram of powder being used per pad. Five normal adult bedbugs were placed in a jar and exposed to a treated pad for 15 minutes. The pad was then removed and the bugs were held for mortality counts 24 to 96 hours later. Fresh bugs were exposed to treated pads as long as complete mortality was obtained. Each test was run in triplicate.

Five per cent of DDT in a mixture of dimethyl phthalate and acetone and 1 per cent of DDT in deodorized kerosene gave complete mortality up to 39 days after application. A dust containing 0.3 per cent of pyrethrins and an activator in pyrophyllite gave complete kill for 2 days after application and partial kill up to 49 days, and a dust containing 5 per cent of DDT in various diluents gave complete kill up to 49 days and 87 per cent mortality 56 days after application.

CAGE TESTS.—In order to simulate natural conditions more closely, further tests were conducted in cages with glass sides and unpainted plywood top and bottom, 30 by 30 by 31 inches inside dimensions. Each cage contained a miniature mattress and was fitted with demountable unpainted wooden walls extending halfway up the inner sides and providing many places of concealment for bedbugs. Spray was applied to the mattress and lower half of a cage at the rate of 100 to 150 milligrams per square foot of surface. Fresh bedbugs were introduced at weekly intervals after spraying and exposed for 48 hours.

In these tests 20 per cent of DDT in orthodichlorobenzene applied at the rate of 100 milligrams per square foot gave complete mortality 73 days after treatment. Previous jar tests had shown that orthodichlorobenzene alone gave no residual kill. It is noteworthy that in a cage receiving the same treatment but scrubbed with hot water and soap 8 days later 100 per cent mortality was obtained 78 days after treatment. A spray containing 0.5 per cent of pyrethrins plus 2 per cent of N-isobutylundecylenamide in deodorized kerosene applied at the rate of 2.5 milligrams of pyrethrins per square foot gave kills from 60 to 80 per cent up to 22 days after treatment and after that time was practically worthless.

PRACTICAL TESTS.—A number of practical tests in infested houses have been initiated, the majority of which are still in progress. Sprays are applied to a bedstead, springs, and mattress, and to the floor and walls near the bed. In these tests not only are the treated beds subject to normal reinfestation, but in addition fresh bugs are introduced at weekly intervals and recovered 48 hours later. The most important of these tests are summarized in table 1. Although the longest period of protection has been obtained with a 20 per cent concentration of DDT, it is believed to be mainly because this solution was applied during the early stages of the investigation and thus more time has elapsed since the material was applied. The passage of time may show that the 5 per cent concentration affords complete protection for a comparable period.

Table 1.—Duration of toxicity of DDT spray residue to bedbugs when applied to beds in infested houses.

SPRAY	AMOUNT OF SOLUTION APPLIED	TIME AFTER TREATMENT THAT 100 PER CENT MORTALITY WAS RECORDED
	Milliliters	*Days*
20% of DDT+40% of orthodichlorobenzene in deodorized kerosene	140	281
5% of DDT in kerosene	195	64
	250	84
5% of DDT aqueous emulsion[1]	250	133
10% of DDT+5% of cyclohexanone in kerosene	250	104

[1] 25% DDT+25% *Wetsit* (alkylated aromatic sulfonate) +50% xylene, emulsified in 4 parts of water.

In several small tests in army barracks located in Florida, 5 per cent of DDT in kerosene has been effective for several months. A large-scale practical test with the same solution is now in progress in central Florida involving the treatment of about 80 barracks, some of which were heavily infested. Complete freedom from bedbugs has been recorded for nearly 4 months.

Although a number of effective solvents and concentrations of DDT have been found, it is concluded that from a practical standpoint 5 per cent in crude kerosene is probably the most satisfactory to use, particularly under military conditions. Kerosene is

[1] Work done at the Orlando, Fla., laboratory.

[2] Acknowledgement is made of the assistance of Howard A. Jones on the chemical aspects of the problem.

cheap, almost universally available, reduces the fire hazard, and will not cause staining. The solution should be applied in the form of a coarse spray in sufficient quantities to obtain a heavy, even deposit of DDT. To insure the most lasting results at least 100 milligrams of DDT should be applied per square foot.

Mortality of Bedbugs on Rabbits Given Oral Dosages of DDT and Pyrethrum[1]

ARTHUR W. LINDQUIST, E. F. KNIPLING, HOWARD A. JONES, and A. H. MADDEN

In the course of rearing bedbugs on rabbits for insecticidal tests, the writers conducted a number of tests to determine whether insecticidal action can be effected through the blood of the host by oral administration of insecticides. When bedbugs were given blood meals on rabbits that had previously been given DDT or pyrethrum, definite insecticidal action was demonstrated in many of the tests.

Adult bedbugs, *Cimex lectularius* L. and *C. hemipterus* F., which had been reared on normal rabbits, were used in these tests. From 12 to 15 bugs were allowed to feed through a screen on the shaved abdomen of the rabbit before treatment. No mortality of bedbugs occurred. The insecticide was then administered orally by capsules or through a rubber tube, care being taken that none of the material touched the rabbit's skin. New lots of 12 to 15 bugs were then fed on the rabbit through a screen for 5 minutes at intervals of approximately 1.5 to 3 hours after treatment. Tests usually were discontinued after 7 to 8 hours, but in some cases bugs were allowed to feed at 10, 12, and 24 hours.

Table 1.—Mortality of bedbugs feeding on mature rabbits given oral dosages of DDT or pyrethrum.

Dosage, Milligrams per Kilogram	Per Cent Kill of Bedbugs Feeding on Rabbits after Treatment						
	1.5	3	5–6	7–8	10	12	24
	hours						
				DDT:			
537	0	30	10	100	50	—	80[1]
456	12	77	87	62	—	—	—
400	30	100	100	90	—	—	—
275	0	0	11	60	60	—	—
273	0	0	60	10	—	—	—
270	10	0	60	60	—	—	—
228	0	100	77	—	—	—	44
				Pyrethrins:			
400	10	90	100	100	—	100	—
	57	50	50	70	—	60	—
	0	50	78	78	—	—	—
	70	50	10	70	—	—	—
	100	100	90	100	—	—	—
336	100	100	100	100	100	100	0
300	0	30	70	40	—	—	—
250	30	50	30	0	—	—	—
				Pyrethrins+N-isobutylundecylenamide:			
400+300	90	67	100	100	80	—	—
	90	90	80	90	—	—	—
	100	100	90	100	—	—	—
350+500	0	50	40	60	—	—	—
300+500	10	44	50	50	—	—	—
300+200	30	80	100	80	—	10	—
	60	60	100	80	—	30	—
200+500	0	40	10	10	—	—	—
100+500	0	80	20	20	—	—	—

[1] Rabbit died after 64 hours.

[1]Work done at the Orlando, Fla., laboratory.

The data are given in table 1. These tests were made from February to July 1943, but four other tests with DDT and pyrethrum in November failed to kill the insects.

Mortality as high as 100 per cent occurred when the bugs were allowed to feed 3 to 5 hours after DDT was administered in dosages from 228 to 400 milligrams per kilogram of body weight. Because of the method of administration, the mortality can be attributed only to ingestion by the bug of the insecticide present in the blood or tissues of the host. Some dosages showed toxic effect on the rabbit.

Pyrethrum extract gave similar results, but the knock-down of the bedbugs was faster. With pyrethrum 100 per cent knock-down usually occurred, but some insects recovered in a few hours. In some cases paralysis set in before the end of the 5-minute feeding period and the bugs did not engorge completely. Stableflies, which fed on a few of these rabbits, showed typical pyrethrum paralysis in less than a minute. Dosages of 250 to 400 milligrams of pyrethrins per kilogram of body weight did not appear to be injurious to the rabbits.

The addition of N-isobutylundecylenamide, a compound known to synergize pyrethrum on some insects, did not increase the kill of bedbugs.

Effectiveness of DDT in the Control of Ticks on Vegetation

CARROLL N. SMITH and HARRY K. GOUCK

In a recent paper the authors discussed the importance of destroying ticks where they are concentrated on vegetation. Several materials gave satisfactory control when used as sprays, but were either injurious to vegetation or contained critical materials. Preliminary observations on DDT indicated that it might be effective against the ticks, and noninjurious to vegetation.

Small laboratory experiments were conducted to determine the relative value of various solvents and emulsifiers for use in preparing DDT sprays for this purpose. On the basis of preliminary experiments, kerosene, mineral oil, and castor oil were eliminated as solvents inferior to benzene, pine oil, and xylene; therefore, the last three were subjected to more detailed comparisons.

Each solvent was tested in combination with four emulsifiers, and each combination was tested with three strengths of DDT (0.2, 0.1, and 0.05 per cent) against *Amblyomma americanum* (L.) (lone star tick), and with two strengths (0.02 and 0.01 per cent) against *Ixodes ricinus scapularis* Say (black-legged tick). Ten reared adults of *A. americanum* were dipped in each of the 36 mixtures, and the entire series was repeated once. All the ticks were from one rearing lot, and hence of the same age and resistance. Twenty adults of *I. ricinus scapularis* collected in nature were dipped in each of the 24 mixtures, and the entire series was repeated once.

In table 1 the results are summarized, each figure showing the average survival of all lots having the same solvent and emulsifier, including all strengths of DDT. Thus each figure for *Amblyomma americanum* is based on 60 ticks in 6 lots and each figure for *Ixodes ricinus scapularis* is based on 80 ticks in 4 lots. The percentages of ticks active after 1 day and alive after 6 days are given, as the desirable elements in a spray are quick knockdown and eventual kill.

It will be noted that in each instance the survival was lowest when pine oil was used as the solvent and

Table 1.—Relative effectiveness of DDT emulsions prepared with various solvents and emulsifiers for the control of ticks on vegetation.

Solvent	Emulsifier	Per Cent Active after 1 Day		Per Cent Alive after 6 Days	
		Amblyomma americanum	*Ixodes ricinus scapularis*	*Amblyomma americanum*	*Ixodes ricinus scapularis*
Benzene	*B-1956*[1]	90	56	57	34
	Triton 720[2]	95	91	88	89
	Dreft[3]	95	49	80	40
	Areskap 50[4]	93	71	53	25
Pine oil[5]	*B-1956*	19	12	5	3
	Tritton 720	77	72	52	51
	Dreft	77	61	48	31
	Areskap 50	10	0	3	0
Xylene	*B-1956*	63	74	23	30
	Triton 720	72	85	38	68
	Dreft	82	46	33	33
	Areskap 50	93	74	77	28

[1] A phthalic glyceryl alkyd resin.
[2] Sodium salt of aralkylpolyether sulfonate.
[3] Sodium lauryl sulfate.
[4] Sodium monosulfonate of monobutyldiphenyl.
[5] Standard grade, destructively distilled.

Table 2.—Control of *Ixodes ricinus scapularis* on roadside vegetation.

Treatment	Quantity per 100 Feet of Road	Ticks Collected Before Treatment	Per Cent of Original Infestation Collected after Treatment					
			1 day	2 days	3–4 days	5–6 days	10–11 days	21–22 days
January 6, 1944								
DDT spray (DDT 0.1%, pine oil 0.5%, *Areskap 50* 0.1%, water 99.3%)	1.3 gal.	241	0	—	0.5	0.5	0.5	1
Sodium fluoride-nicotine sulfate spray (NaF 1.5%, *Black Leaf 40* 0.5%, *Dreft* 0.1%, water 97.9%)	1.0 gal.	87	3	—	0	6	11	48
Check area (no treatment	—	81	101	—	22	48	69	107
January 7								
DDT dust, 1% in pyrophyllite	7.0 oz.	143	—	—	0	2	2	29
Check area (no treatment)	—	160	—	46	34	68	—	107
January 18								
DDT spray (DDT 0.05%, pine oil 0.25%, *B-1956* 0.1%, water 99.6%)	0.4 gal.	142	2	2	0	—	37	—
Check area (no treatment)	—	109	79	51	59	—	157	—
January 18								
Derris dust (ground root, 4% rotenone), 75% in pyrophyllite	7.7 oz.	74	13	5	1	—	18	—
DDT dust, 0.1% in phyrophyllite	9.4 oz.	110	4	3	3	—	35	—
DDT dust, 0.5% in pyrophyllite	7.7 oz.	122	1	2	0	—	16	—
Check area (no treatment)		56	101	77	50	—	155	—

Areskap 50 as the emulsifier, although pine oil and *B-1956* gave almost equally good results. All other combinations were distinctly inferior in these tests.

Field tests were conducted with DDT as a spray and as a dust for the control of adult *Ixodes ricinus scapularis*. The dusts were prepared by dissolving DDT in acetone and adding the solution to pyrophyllite, but as the acetone presumably evaporated, it was not considered in calculating the final percentage of DDT in the dust. As the ticks tend to concentrate along roads and paths, the tests here reported include treatment of roadsides only. The treated areas ranged from 484 to 1362 feet in length. Collections were made with a drag, before treatment and at intervals after treatment, and all ticks were returned to the vegetation as collected. The abundance of ticks following treatment with DDT was compared with the abundance in untreated areas and in areas dusted with derris or sprayed with a nicotine sulfate-sodium fluoride mixture, formerly considered the most effective treatments known.

The results of the field tests are presented in table 2. It will be noted that abundance in the untreated areas was very erratic, but remained high enough to indicate that the extreme reduction obtained in treated areas was in fact due to the treatment. For the first 10–11 days after treatment, sprays containing 0.1 per cent of DDT were at least as effective as the nicotine sulfate-sodium fluoride, and the dusts containing 1 and 0.5 per cent of DDT were as effective as the derris dust or the sprays. Dust containing 0.1 per cent of DDT was less effective than the stronger dusts. By 21–22 days the spray containing 0.1 per cent of DDT was far more effective than the nicotine sulfate-sodium fluoride spray or the 1 per cent DDT dust.

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DDT in the Control of Ticks on Dogs

HARRY K. GOUCK and CARROLL N. SMITH

BROWN DOG TICK.—Emulsions containing 5 per cent of DDT gave satisfactory control of the brown dog tick, *Rhipicephalus sanguineus* (Latr.), when applied as washes. The emulsions were prepared by dissolving 5 parts of DDT in 6¼ parts of benzene, adding 1¼ parts of an emulsifier, and pouring this slowly into 87½ parts of rapidly stirred water.

A hound heavily infested with ticks in all stages of engorgement was washed in an emulsion containing B-1956[1] as the emulsifying agent 9 days after its preparation. The dog was caged over a moat, from which the ticks were collected daily for 10 days. Within 1½ hours after treatment 27 females one-fourth to fully engorged, 46 flat females, 87 males, and 2 engorged nymphs had dropped from the dog in a moribund condition and were dead within 24 hours. Over the 10-day period 36 engorged nymphs, 520 males, 391 flat females, 198 females, one-fourth to one-half engorged, 149 females one-half to fully engorged, and 19 females fully engorged had dropped. All were dead or died within 48 hours. At the end of the period all the engorged or partly engorged ticks had dropped, but several hundred dead flat ticks were still attached.

[1] All four of the emulsifiers mentioned are materials which are sold under trade designations. The results reported are based on the particular samples received, and assurance cannot be given that there will not be variation between lots.

The same emulsion was tested a month after its preparation on a wire-haired terrier that was lightly infested with flat adult ticks. Three hours after treatment the ticks appeared to be moribund, and 3 days after treatment the few remaining were dead.

Two short-haired dogs, both lightly infested with flat adult ticks, were washed in an emulsion containing 5 per cent DDT with *Dreft* as the emulsifier. Three hours after treatment all ticks were moribund and after 3 days all were dead.

One long-haired dog infested with hundreds of adult ticks was washed in an emulsion containing 5 per cent of DDT with *Vatsol OS* as the emulsifier. The following day most of the ticks were dead, and by the third day after treatment the few ticks that remained on the dog were dead.

A long-haired dog heavily infested with ticks in all stages of engorgement was washed in an emulsion containing 2 per cent DDT with *B-1956* and *Areskap* as the emulsifiers. After being dipped the dog was caged over a moat, from which the ticks were collected daily. During the 5-day period 17 engorged nymphs, 54 males, 34 flat females, 4 females one-fourth to three-fourths engorged, and 11 fully engorged females were collected dead, whereas 14 engorged nymphs and 2 fully engorged females dropped alive. At the end of the 5 days all remaining ticks were picked from the dog. Of these, 7 engorged females, 5 females one-fourth to three-fourths engorged, 38 flat females, and 108 males were dead, whereas 14 engorged females were alive. In the picking the ticks it was noticed that dead males were attached under the live engorging females.

A cocker spaniel infested with thousands of ticks in all stages of engorgement was dusted with 10 per cent DDT in pyrophyllite and kept over a moat. During a 10-day period the following collections were made: 1149 males, all dead; 1097 flat females, all dead; 36 females one-fourth to one-half engorged, all dead; 165 females one-half to fully engorged, of which 143 were dead or died subsequently; 361 fully engorged females, of which 293 were dead or died subsequently; and 135 engorged nymphs, of which 92 were dead or died subsequently. The females that were not killed oviposited. At the end of the 10-day period a large number of dead flat ticks remained on the dog.

LONE STAR TICK.—An emulsion containing 5 per cent DDT with B-1956 as the emulsifier was effective in controlling larvae of the lone star tick, *Amblyomma americanum* (L.). One short-haired dog heavily infested with larvae was washed with the emulsion and caged over a moat from which the ticks were collected daily. The collections included large numbers of dead flat larvae and 1228 dead engorged larvae. No live ticks were found at any time. All ticks had been dislodged by the seventh day after treatment.

About 30 cubic centimeters of a solution containing 20 per cent DDT in benzyl benzoate was applied to a collie by means of an atomizer. The dog was then allowed to run in an infested area and kept in a cage over a moat from which the ticks were collected daily. The treatment was not satisfactory, for all the ticks that attached completed engorgement, although many died after dropping. Only 46 of the 105 nymphs and 3027 of the 6707 larvae that completed engorgement lived to molt.

In both these tests a check dog was heavily infested with ticks that engorged normally.

None of the dogs treated with DDT showed any ill effects from the treatment.

DDT, Sulfur, and Other Insecticides for the Control of Chiggers

CARROLL N. SMITH and HARRY K. GOUCK

During the past season the effectiveness of DDT, as compared with sulfur and several other materials heretofore considered control agents for these pests, in wooded areas in Georgia and South Carolina.

Satisfactory comparisons of chigger abundance were obtained by collecting them on a piece of black oilcloth, 1 foot square, folded loosely once so that the unfinished surface was on the inside. When the oilcloth was placed on the ground, the chiggers ran up from the under surface and remained on the upper surface near the highest point. After 1 minute the oilcloth was removed from the ground, unfolded, and placed with the finished side up on a field table. The chiggers, which were easily seen running over the material, were removed by touching them with scotch tape or by crushing them with a smooth stick. In heavily infested spots 50 or 60 chiggers were often collected in 1 minute, but the average was about 20 per minute.

In Georgia the chiggers were abundant about the bases of certain living trees, but scarce on the ground 5 or 6 feet away from the trees. H. E. Ewing determined a sample from this area as *Eutrombicula alfreddugesi* (Oud.). In South Carolina, although chigger abundance was equally sporadic, it was not associated with living trees, the heaviest concentrations occurring near decaying wood or in open spaces covered with dead leaves. Specimens from this area were determined by Dr. Ewing as *Acariscus masoni* Ewg. Both species are pests of man.

In the tests against *Eutrombicula alfreddugesi*, plots 10 feet square were marked off about the bases of infested trees. The chigger infestation was usually entirely within the limits of the plot. Four 1-minute collections were made in each plot, two within a foot of the tree and two near the margin. The dusts were applied with a hand duster. In the tests against *Acariscus masoni* the plots were 10 by 20 feet, and rarely included trees. Six 1-minute collections were made in each plot, some near decaying wood if any was present. In both cases collections after dusting were made at the same sites and in the same manner as the original collections.

It would have been preferable to return the chiggers to the ground after counting them, but their small size and great activity made it impossible to handle them rapidly enough when 30 or 40 were collected at once. They were therefore destroyed. Fortunately, the abundance was not appreciably diminished by destroying them, as indicated by the collections in the check area.

The tests on the control of *Acariscus masoni* are summarized in table 1. The materials that gave the best control were sulfur, dinitro-o-cresol, and DDT. Elemental sulfur appeared to be slightly superior to wettable sulfur. On the first day after dusting with this material, chigger abundance was only 9 to 17 per cent of the original infestation, and it continued to decline thereafter. In two of three tests all

Table 1.—Control of the chigger Acariscus masoni by dusting with varous insecticides, 1943.

Insecticide	Rate Pounds per Acre	Chiggers Collected before Dusting	Per Cent Collected After Dusting							
			1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days
Dusts applied August 10										
Thylox[1] sulfur	ca. 150	172	15	24	—	13	—	—	—	3
Tobacco dust	ca. 150	113	70	36	—	78	—	—	—	237
Cryolite	ca. 150	84	57	25	—	—	—	52	—	—
Check, no treatment	—	72	118	100	75	117	—	—	—	76
Dusts applied August 20										
Elemental sulfur	168	127	17	—	7	—	11	—	—	0
Wettable sulfur	182	86	20	—	8	—	7	—	—	6
Check, no treatment	—	47	121	—	81	—	130	—	—	53
Dusts applied August 27										
Sodium fluoride	90	73	59	—	86	—	141	—	—	68
Elemental sulfur	76	44	9	—	9	—	7	—	—	5
Dinitro-o-cresol, 10 per cent[2]	60	101	0	—	4	—	3	—	—	1
Phenazine, 4 per cent[2]	68	58	16	—	31	—	22	—	—	10
Pyrophyllite, alone	71	38	60	—	71	—	45	—	—	58
Check, no treatment	—	34	129	—	94	—	53	—	—	41
Dusts applied September 6										
Elemental sulfur	57	74	12	4	—	3	—	—	0	—
Dinitro-o-cresol	60	120	0	0	—	2	—	—	7	—
DDT, 2 per cent[2]	32	54	0	0	—	2	—	—	2	—
Check, no treatment	—	45	127	89	—	107	—	—	89	—
Dusts applied September 7										
Diphenylamine, 5 per cent[2]	27	46	30	—	28	—	—	43	—	17
Check, no treatment	—	57	70	—	84	—	—	70	—	32

[1] This material is sold under trade designations, for which there is no adequate chemical description. The results reported are based on the particular sample received, and assurance cannot be given that there will not be considerable variation between lots.
[2] In pyrophyllite.

Table 2.—Control of the chigger, *Eutrombicula alfreddugessi*, by dusting with various insecticides. Dusts applied August 24, 1943.

Insecticide	Rate of Applications, Pounds per Acre	Number of Chiggers Collected Before Dusting	Per Cent of Original Infestation Collected After Dusting		
			1 day	3 days	7 days
Cryolite	81	46	39	44	50
Elemental sulfur	96	98	14	6	2
DDT, 1 per cent in pyrophyllite	125	79	6	6	19
Check, no treatment	—	31	125	113	132

chiggers were eradicated in 8 days. It gave satisfactory control at the minimum rate of 57 pounds per acre. Applications of 5 per cent dinitro-o-cresol and 2 per cent DDT were followed by complete absence of chiggers for 2 days, after which a few reappeared. Reductions of 50 to 80 per cent were obtained with phenazine and diphenylamine.

The tests against *Eutrombicula alfreddugesi* are summarized in table 2. Results were similar to those against the previous species, DDT appearing best on the first day, sulfur on the seventh day, and the two equal on the third day. Cryolite was less effective.

DDT for Control of Gulf Coast and Spinose Ear Ticks

C. S. RUDE and CHARLES L. SMITH

During the summer of 1943 tests were conducted on the ears of range cattle in the coastal section of Texas with various materials for the control of the Gulf Coast tick, *Amblyomma maculatum* Koch. Among the materials tested was DDT incorporated into a nondrying adhesive that had been used for this purpose by E. B. Blakeslee at Panama City, Fla. The mixture was applied to the inside of the outer ears and to the outside of the ears for destruction of ticks that crawled upon the material. Three hundred and three cattle were treated with two mixtures containing DDT, with no apparent injury to the animals. When a 2 per cent DDT mixture was used, about 10 per cent of the normal number of adult ticks attached to the ears, but when a 5 per cent DDT mixture was used, few adult ticks were able to attach for engorgement. The 5 per cent material gave a highly satisfactory kill of the ticks present at the time of treatment and afforded a high degree of protection from reinfestation for three weeks. This is approximately three times as long as the protection period afforded by any of the remedies now being used by the ranchmen.

Tests were also conducted in the vicinity of Menard, Tex., with DDT for the control of the spinose ear tick, *Ornithodoros megnini* Dugès, on cattle. A nondrying adhesive that contained 5 per cent of DDT was applied to the inside of the ears of 113 cattle, with no observed injury to the animals. The material gave a high percentage kill of the ticks present at the time of treatment and afforded some protection from reinfestation. Although the results were less satisfactory than those obtained with the Gulf Coast tick, they were of sufficient interest to justify further tests against this important parasite.

The Effectiveness of DDT as a Residual Spray Against Houseflies

ARTHUR W. LINDQUIST, A. H. MADDEN, H. G. WILSON, and HOWARD A. JONES[1]

Investigations begun in February 1943 at Orlando, Fla., showed that DDT, when sprayed on surfaces in a suitable solvent, remains as a nearly invisible deposit after the liquid has volatilized, and acts as a residual contact insecticide on houseflies. Some of the results obtained in these studies are presented in this paper.

METHODS.—The interiors of wooden boxes, screen and glass containers, and rooms were sprayed with known amounts of DDT in different formulas. At intervals thereafter, reared 4-day-old houseflies were introduced and the time required to knock down 50 and 100 per cent of the flies was recorded. The flies were recorded as down when they were on their backs and unable to crawl. After 115 days the tests were discontinued until winter, when the final records were made after 265 days. Tests were conducted at room temperatures, which ranged from 80° to 90° F. in the spring and summer and averaged 80° in the winter. Suitable checks showed no mortality during the test periods.

EFFECTIVENESS OF DDT IN DIFFERENT SOLVENTS.—Many solutions, emulsions, and suspensions containing DDT have been tested. Table 1 shows the results with a few of the formulas used when applied in unpainted wooden cages at the rate of 25 milligrams of DDT per square foot. The dibutyl phthalate formula was less effective than the formula with ethylene dichloride or kerosene. Of all the solvents tested, kerosene appeared to be the most desirable for the immediate use of the armed services.

It will be observed that the knock-down was much faster after 265 days than after 115 days. In these tests the cages were sprayed on April 13, and the knock-down time increased progressively from between 15 and 41 minutes at 15 days to approximately 400 minutes at 115 days. Although the 265-day tests were made at a slightly lower temperature than were the tests made during the summer, temperature does not appear to be entirely responsible for the differences in knock-down. Perhaps a combination of temperature and the exuding of DDT from the wood is a factor.

DDT ON DIFFERENT SURFACES.—When various mixtures containing DDT were applied to painted and unpainted wood surfaces, most of the sprays proved less effective on surfaces painted 2 to 3 weeks before being sprayed than on unpainted wood. This

[1]Work done at the Orlando, Fla., labbratory.

Table 1.—Time required for complete knock-down of houseflies when introduced into unpainted wooden cages sprayed with 5 per cent of DDT in various solutions and emulsions.

Days between Spraying and Exposure of Flies	Minutes before Knock-Down Was Complete Following Sprays of DDT in						
	Ethylene Dichloride	Dibutyl Phthalate	Ethylene Dichloride Emulsion[1]	Dibutyl Phthalate Emulsion[2]	Kerosene	Benzyl Benzoate-Deodorized Kerosene[3]	Benzyl Benzoate-Deodorized Kerosene Emulsion[4]
15	30	20	32	41	15	23	17
20	58	63	44	115	29	29	28
26	59	115	56	222	37	46	33
33	73	172	47	280	60	57	57
45	58	382	55	384	92	102	53
53	48	390	54	390	122	116	64
60	67	259	92	245	92	112	76
67	108	262	101	453	166	128	123
75	82	202	50	230	70	91	72
80	81	403	142	428	87	80	84
86	156	321	275	420	156	94	106
93	301	326	297	422	300	233	316
100	—	—	—	—	222	319	344
115	314	—	—	356	438	402	450
265	80	—	—	125	103	97	109

[1] 20% ethylene dichloride, 4% *Vatsol OT* (dioctyl sodium sulfosuccinate) in water.
[2] 20% dibutyl phthalate, 4% *Vatsol OT* in water.
[3] 10% benzyl benzoate, 85% *Deobase* (deodorized kerosene).
[4] 10% benzyl benzoate, 10% *Dobase*, 0.5% *Vatsol OT* in water

is believed to be due to the action of the solvents on the paint. The difference was not pronounced on surfaces that had been painted for some time. A suspension prepared by mixing 10 parts of a finely divided DDT-talc mixture and 2 parts of a wetting agent, such as sodium lauryl sulfate, gave excellent kills up to 75 days on painted surfaces, although its use may be limited because of the visibility of the residue.

DDT has been used on plastered walls with good results. It is highly effective when used on cages of both metal and plastic screen, although some of the solvents in which DDT is used may react unfavorably on plastics. The sprays are sufficiently effective on all types of surfaces to be of distinct value in control.

Effect of Dosage on Mortality.—Several tests in which DDT was applied in boxes at different dosages showed a gradually increased speed of knock-down from 10 to 200 milligrams per square foot, but no appreciable difference between 200 and 400 milligrams per square foot. Flies have been knocked down and killed by dosages as low as 0.25 milligram per square foot. The larger dosages retain residual toxic action for longer periods.

Effect of Short Exposure Periods.—A large number of tests were made in which flies were exposed to DDT-treated surfaces for 1 to 5 minutes and then placed in clean cages for knock-down counts at 6 hours and mortality counts at 24 and 48 hours. Two wooden boxes, one sprayed with 5 per cent of DDT in deodorized kerosene and cyclohexanone, and the other with 5 per cent of DDT in kerosene at the rate of 125 milligrams of active material per square foot, gave kills of 86 and 65 per cent respectively, after 1-minute exposure 158 days after treatment. Five-minute exposure in the same boxes caused nearly 100 per cent kill. Screen-wire cages treated at the rate of 100 milligrams of DDT per square foot gave a mortality of nearly 100 per cent of flies exposed for 5 minutes 151 days after treatment. In these tests the knock-down at 6 hours was usually low. The mortality was practically the same at 48 hours as at 24 hours, indicating that DDT did not have a delayed action after the first day.

Effect of Temperature on Knock-Down and Kill.—To study the effect of temperature on kill, flies were exposed at 65° F. in boxes treated with DDT and when all were down (40 minutes) they were divided and transferred to clean cages and kept at various temperatures. Records made at 18 hours

Table 2.—Number of flies taken in dairy barns before and at intervals after one spraying of walls and ceiling with 5 per cent of DDT in kerosene, and with a commercial insecticide.

Days after Treatment	Barn Sprayed with DDT		Small Barn Sprayed Daily by Owner with Commercial Insecticide	Untreated Barn (Average)
	0.335 milligram per square foot	0.325 milligram per square foot		
Before spraying	1500	1800	—	—
7	60	102	—	1200
9	100	111	—	—
12	140	74	—	—
15	26	36	—	1700
18	24	39	—	—
21	12	36	470	—
26	39	12	203	925
29	10	20	81	—
33	16	42	478	—
36	31	34	125	880
39	32	55	153	—
47	114	16	286	780
53	15	10	77	—
68	4	18	65	560
77	12	35	44	695
83	15	7	—	—
97	20	8	—	268
165	26	12	—	212

showed 100, 92, and 86 per cent kill when flies were kept at 70°, 90°, and 100°, respectively. Exposures were also made at 95°, and when all flies were down (95 minutes) they were divided and held at 70°, 90°, and 100°. In 18 hours the kill was 100, 100, and 98 per cent, respectively. These tests demonstrate that a small percentage of flies will recover from knock-down when exposed at 65° and subsequently kept at 90° and 100° but that exposure at 95° allows slight recovery.

PRACTICAL SPRAY TESTS.—The walls and ceilings of the milk barn and feed room of a number of dairies were sprayed once with 5 per cent of DDT in kerosene. Results were evaluated by making 15 sweeps at designated places in the barns before treatment and at intervals thereafter. The results are given in table 2. The immediate reduction of flies was approximately 95 per cent, and for several months the population continued to be much lower than in untreated barns.

Residual Effect of DDT Against Houseflies

E. R. VAN LEEUWEN

Experiments were conducted at the Beltsville Research Center to ascertain the period of time that DDT can be depended on to prevent an accumulation of houseflies, *Musca domestica* L.

SMALL-CAGE TESTS.—Two cages 9½ inches on each side, consisting of screened sides, a glass door, and a metal bottom, were used. One cage was sprayed on the inside with 21 cubic centimeters of a 2 per cent solution of DDT in kerosene, and the other with 92 cubic centimeters of a 1 per cent suspension in water. Both cages were treated on May 3, 1943. Houseflies were liberated in the cages during the period May 3 to September 22. All the flies were on the floor of the cage within 45 to 75 minutes after admission, and none recovered.

LARGE-CAGE TESTS.—A cage 4½ by 3½ by 6⅔ feet, with four solid sides and bottom and a screened top, was sprayed on the inside with 280 cubic centimeters of a 1 per cent suspension of DDT in water. The spray was applied on May 21, 1943. The first flies liberated were all on the bottom of the cage at the end of 60 minutes, and none recovered. Between this date and September 22 the time required for 100 per cent knock-down increased from 60 minutes to 120 minutes. None of the flies recovered.

SMALL DAIRY-BARN TESTS.—A room 20 by 20 by 10 feet in a dairy barn was treated on June 12, 1943, with 6 gallons of water containing 1 per cent of DDT, 1 per cent of pyrophyllite, and 0.5 per cent of sodium lauryl sulfate. The four windows in this room were screened. No animals were allowed in the room. The first flies were released into this room on June 19 and other releases were made at irregular intervals up to September 23. The time required to obtain 100 per cent knock-down of flies varied somewhat during the season. The first releases required approximately 75 minutes, whereas the last release (September 23) required 120 minutes. All these flies succumbed. The outstanding observation made in connection with this test was that the residue on the walls did not lose its toxicity appreciably in an open barn during a period of 103 days.

LARGE DAIRY-BARN TESTS.—To determine the effect of DDT on flies under actual conditions, a dairy barn was sprayed with a 1 per cent suspension on June 28, 1943. This barn, according to the herdsman, was the most heavily infested and the most difficult to keep free of flies of the 12 barns in the group. The barn was 140 feet long, 36 feet wide, and the ceiling 8½ feet high. The walls and ceiling were painted white. The capacity of the barn was 40 cows.

The material was applied with a small power sprayer at 150 pounds' pressure and with a fairly coarse spray. A total of 200 gallons was used, or sufficient to wet the ceiling and the upper two-thirds of the walls without permitting any run-off.

Areas on the walls and ceiling were selected for making counts of the fly population. Before the DDT was applied, 312 flies were counted on the 13 selected areas. Following the application 38 observations were made from June 29 to October 8. The maximum number of flies at any one time was 56, the minimum 0, and the average for the entire period 10.8.

Since the counts were made between 1 and 3 p.m., which was at a time when flies were entering the barn to feed, no doubt many of the flies counted had not been in contact with the DDT long enough for it to take effect. When the doors and windows of the barn were closed for 4 hours, all flies succumbed.

MISCELLANEOUS TESTS.—During the summer nine other barns, including a sheep barn and a swine barn, were treated with DDT. In every case the infestation of flies was completely destroyed and no considerable number of flies accumulated in any of the barns after the treatments.

DDT as a Barn Spray in Stablefly Control

E. B. BLAKESLEE

During September and October 1943 several fairly large scale tests were made with DDT as a barn spray for the control of the stablefly, *Stomoxys calcitrans* (L.), also called the dog fly in the southern states.

The tests were made in two screened horse barns located on the beaches along the Gulf Coast between Pensacola and St. Marks, Fla. Three applications, 10 to 12 days apart, were made to each barn, with a solution of DDT in white kerosene, at a concentration of 2 grams to 100 cubic centimeters. The spray was applied as a mist with a small knapsack sprayer. Approximately 8 gallons of material was applied to 2,000 square feet of wall surface, which was enough to wet it without run-off.

Previous to the DDT treatment the 44 horses stabled in the two barns were held inside during bad fly outbreaks, and a commercial fly spray was used to keep down flies. After the applications of DDT, no further sprays were necessary to protect the animals. There was no evidence that the spraying reduced the number of flies congregating outside the barns.

Daily fly counts on two treated and two untreated animals failed to indicate any significant permanent reduction, although a startling reduction was observed for a few hours following treatment. In one instance with an outside population of 200 flies per animal a reduction to almost zero was noted in the immediate vicinity of the barn, while 50 feet away

in the brush countless thousands were present. By the following day, however, flies were present in enormous numbers on the outside of the barn, the mortality rate apparently being too slow to affect the enormous outside population. Moribund and dead flies were easily found at all times along the base of the barn walls.

In a test to determine the number of days DDT remains effective when applied in buildings, at one unsprayed barn a single window screen treated with DDT in kerosene, 5 grams to 100 cubic centimeters, was still killing flies at the end of 13 days, when the observations were terminated. At another barn an unoccupied section of eight stalls, screened from the remainder of the barn, was treated with 2 grams of DDT per 100 cubic centimeters of kerosene. The doors were left open each morning and thousands of flies allowed to enter the compartment during the day. In the evening the doors were closed, and the following morning the room was examined for live flies. A 100 per cent kill was obtained for 12 days. Unfortunately this room had to be used for horses at the end of that time and the experiment ended. It was observed, however, that appreciable protection to the horses inside the barn seemed about over.

As fly sprays on animals DDT has been used in various solvents. These sprays have been applied to horses in 4-ounce doses, twice daily for as many as 35 applications, and in all instances they have given a 100 per cent knock-down and kill of flies alighting on the animals.

No repellent effect was obtained with DDT, nor did it increase or reduce the repellency of any material to which it was added. Except for its cost, the most efficient combination used was DDT in indalone, at 2 grams per 100 cubic centimeters. When used as a spray on horses, this material gave 100 per cent kill, 1 hour of complete protection, from 2 to 4 hours of satisfactory partial protection, and a residual deposit on the animal that remained toxic to flies for a few days.

The Use of DDT in the Treatment of Manure for Fly Control

S. W. SIMMONS and MIKE WRIGHT

Tests to determine the effectiveness of various strengths of DDT as a larvicide on houseflies breeding in manure were conducted at Panama City, Fla., from November 1943 through January 1944. The material was applied with a power sprayer operating at approximately 350 pounds' pressure, a semi-driving spray, obtained by throttling the gun, being used. The DDT was applied in the form of a water emulsion, which was prepared from a 10 per cent stock emulsion. The stock formula was 10 grams of DDT, 12.5 milliliters of benzene, 2.5 milliliters of *B-1956* emulsifier (phthalic glyceryl alkyd resin), and 75 milliliters of water. This stock emulsion was relatively stable, and could be diluted in the field to establish the desired experimental concentration of DDT.

Cow manure piled in mounds of approximately 16 cubic feet was exposed long enough to insure a good infestation of both larvae and pupae. Each pile was then sprayed with 8 to 10 gallons of the DDT emulsion, or at the rate of about 0.6 gallon per cubic foot. The material was then caged. Counts of the emerging flies were begun two days later, and repeated at two-day intervals. Check piles were established and enclosed in cages at the same time as the treated piles.

On November 15 two piles were treated with 1 per cent DDT emulsion and, with two checks, immediately caged. Counts of emerging flies made over a period of 67 days totaled 13 in the treated aeges and 555 in the checks. Examination of the treated piles two days after spraying showed dead larvae and pupae. In these and all other tests, both larvae and pupae were found in treated and check piles prior to treatment. The presence of mature pupae was further borne out by the emergence of adult flies within two days following treatment.

On December 3 two piles of manure were sprayed with 0.5 per cent DDT emulsion, and caged along with one check pile. Over a period of 65 days 2 flies emerged from the two treated piles, and 1008 from the single check pile.

On January 17 two well-infested piles were sprayed with 0.25 per cent DDT and two with 0.1 per cent DDT and immediately caged along with one check. Over a period of 18 days no flies have emerged from the piles treated with the 0.25 dilution, 2 flies have emerged from the pile treated with the 0.1 dilution, and 940 from the check.

Since benzene is itself an insecticide, tests were made to determine whether the amount used in the DDT emulsions was giving an appreciable kill of the larvae and pupae. Two infested piles were sprayed on January 17 with 10 gallons each of a 1.5 per cent benzene emulsion in water, using *B-1956* as an emulsifier. This concentration represents the amount present in the highest DDT concentration (1 per cent) used in these tests. Counts of emerging flies over a period of 18 days showed 482 and 513 from the treated piles, while the single check pile produced 940 flies. It appears that benzene in the dilution used gave about a 50 per cent kill; however, emergence is not yet complete. These counts should be compared with those obtained when 0.25 and 0.1 per cent DDT dilutions were applied to the same batch of manure and the piles were equally infested. In addition it should be pointed out that a 0.1 per cent DDT emulsion would contain only 0.15 per cent of benzene, and this amount is probably too small to effect any appreciable kill.

Certain strengths of DDT were tested on peanut litter well infested with stablefly (dog fly) larvae and pupae, to check the foregoing tests. Several 2-cubic-foot piles of litter were heavily treated with 2 gallons of spray. Two piles were treated with 0.5 per cent DDT, two with 0.25 per cent DDT, and one pile was caged as a check. Counts over 32 days gave a total of 5 flies from the 0.5 per cent DDT, 2 from the 0.25 per cent DDT, and 204 from the check.

It appears from these preliminary data that effective control of fly breeding can be obtained in manure, when it is thoroughly treated with DDT water emulsions in concentrations as low as 0.1 per cent. Since the minimum lethal dose has not been reached in these tests, further work with more dilute formulas is under way. Adult flies are very susceptible to DDT, and tests are being established to determine if a surface application to manure piles will kill emerging adults. It is not believed that the low concentrations required for control would adversely affect the use of manure as a fertilizer, but clarification of this factor is indicated.

Relative Effectiveness of DDT and Rotenone Against Houseflies

W. T. HUNT

In laboratory tests of insecticides at the Dallas, Tex., station DDT was compared with rotenone in its effectiveness against houseflies.

The insecticides were tested as sprays in deodorized kerosene, by the spray-tunnel method (Eagleson 1940), on laboratory-reared flies 4 to 7 days old. These flies were sprayed in lots of 50, at the rate of 2 milliliters per lot. Each test consisted of from 6 to 10 lots and was replicated several times on different days. Immediately after being sprayed, the flies were transferred to recovery cages for observation. The number of flies active 6 hours after treatment determined the effectiveness of the sprays, these results being substantially the same as when observations were continued 24 hours. No attempt was made to determine the knockdown rate.

The results are summarized in table 1.

Table 1.—Comparative effectiveness of DDT and Rotenone against houseflies when applied as sprays by the spray-tunnel method.

Concentration, Grams per Liter	Percentage of Flies Active 6 Hours after Treatment	
	DDT	Rotenone
0.2	—	62.2
.25	—	57.7%
.5	90.5%	45.8
.75	—	29.4
1.0	57.4	20.3
1.25	52.3	6.8
1.5	—	6.0
2.5	22.2	—
3.75	4.5	—
5.0	3.7	—
10.0	0	—

A spray containing 0.25 gram of rotenone[1] per liter left the same percentage of flies active at the end of 6 hours as a spray containing 1 gram of DDT; and 1 gram of rotenone was about as effective as 2.5 grams of DDT. Therefore, rotenone is 2½ to 4 times as effective as DDT against houseflies when applied by this method. The minimum lethal dose was not determined.

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DDT as a Flyspray on Range Cattle

R. W. WELLS

During the summer of 1943 tests were conducted with DDT in aerosols and emulsions for the control of horn flies, *Siphona irritans* (L.), on beef cattle under ranch conditions in Texas.

AEROSOLS.—Three tests were made with aerosols containing 5 per cent of DDT, 10 per cent of either sesame oil or acetophenone, 20 per cent of trichlorotrifluoroethane (Freon 113), and 65 per cent of methyl chloride. In one test all of 14 cattle in a pasture were sprayed with the aerosol on May 14, when they carried about 500 flies each. On the following day they carried no flies. On the fourth day the only horn flies were 1 to 5 on each of 3 of the animals, and on the seventh day there were 5 to 6 on 1 animal. When next examined, on the fourteenth day, the animals carried 200 to 500 horn flies each. In the same period check herds on the same ranch averaged approximately 1000 flies per animal.

In another test in an adjoining pasture containing 15 cattle, only 7 were sprayed with the aerosol on May 14. Before spraying the number of flies was estimated at 500 per animal. On the following day there were no flies on any of these 15 animals, sprayed or unsprayed. On the fourth day 5 animals carried 3 to 8 horn flies each and 1 unsprayed animal carried 10 to 15 flies; the other 9 carried no flies. On the seventh day a total of only 3 flies was found among them. On the fourteenth day 200 to 500 horn flies per animal were found.

In the third test 5 yearling bulls, the only occupants of a small pasture, were sprayed with the aerosol only over the back and on top of the head, as can be easily and rapidly done over the sides of a chute. All 5 were sprayed on May 15, when they carried 800 to 1,200 horn flies each. On the third day after spraying there were only 4 or 5 horn flies among them, and on the seventh day there were 6. On the thirteenth day the animals averaged approximately 30 flies each, when a bull 100 yards distant in another pasture carried 150 flies, although he had been sprayed on the previous day with a popular oil-base spray, and a check herd half a mile away carried 1500 to 2000 flies each.

These tests indicate that satisfactory control may be obtained for 2 weeks by a single spraying with the aerosol, even if some of the animals escape the treatment and only the backs of the cattle are treated.

In cage tests where definite numbers of flies were exposed on successive days to sprayed animals, the residue from the aerosol did not remain highly toxic to flies after 4 days. The longer protection in pastures is undoubtedly due to the prompt destruction of the existing adult fly population, which is only slowly renewed by newly emerging adults, which might be more susceptible to the residual toxicant in the hair.

Examinations of hair taken from cattle after spraying show that the DDT crystals readily shatter from the hair. Methods of sticking the toxicants to the hair are being studied.

EMULSIONS.—Equally satisfactory control of horn flies was obtained when DDT in emulsions was applied to range cattle with a power sprayer at 300 pounds' pressure. In one operation 90 cattle were sprayed all over with one nozzle in 1 hour. During hot weather, where horn flies resort to the bellies of the cattle, it is considered advisable to spray the bellies as well as the backs. In a chute it is difficult to wet the belly of an animal. A satisfactory method was to let 5 or 6 cattle at one time into a pen small enough so that an operator standing in any corner can reach every other corner readily with the spray stream. As the cattle move around, every part of

[1] An extract containing 5.04 grams of rotenone per 100 cc plus other extractives.

each animal can be sprayed readily without wasting much material. With a No. 4 disk in the nozzle from 2 to 3 pints were used per animal. The cattle were free of flies within 30 minutes after spraying and remained almost entirely free for 7 days. After 14 days they had only one-third to one-half as many flies as untreated herds in other pastures on the same ranch. In one herd that was sprayed a second time 2 weeks after the first spraying, the cattle carried only 50 to 75 horn flies on the twenty-first day after the second spraying, while once-sprayed cattle were again normally infested. It is expected that two sprayings at such an interval will control horn flies during the spring abundance and two more sprayings in the fall will give control at that time.

With a power sprayer no advantage was obtained in using more than 0.2 per cent of the insecticide in the emulsions, but the results were not satisfactory when a 0.1 per cent emulsion was used. When cattle were sprayed with hand sprayers, less than 2.5 per cent was not satisfactory.

Two formulas for preparing the emulsions which gave the best results were as follows: (1) DDT 100 grams, benzene 140 milliliters, kerosene 140 milliliters, and Triton NE 8 grams; (2) DDT 100 grams, benzene 140 milliliters, dibutyl phthalate 140 milliliters, and Triton NE 12 grams. In both cases water was added to make 1 liter. The formula containing dibutyl phthalate proved to be preferable, because this material remains wet and appears to delay the formation and dissipation of the DDT crystals.

These emulsions were found to stand indefinitely and to mix readily with water. In a power sprayer it is advisable to disconnect the agitator to avoid too rapid evaporation of the benzene. Satisfactory mixing can be accomplished by spraying the material back into the tank.

Laboratory Tests on Houseflies with DDT in Contact Sprays

W. A. GERSDORFF and E. R. MCGOVRAN[1]

Preliminary tests have been made on the housefly with contact sprays containing DDT, in comparison with sprays containing pyrethrins. DDT was used alone and in combination with other insecticidal compounds. The DDT used was of technical grade with a setting point of 91° C.

Tests by the turntable method showed that DDT at concentrations above 0.2 per cent (weight per volume) in deodorized kerosene caused a pronounced knock-down in 10 minutes but at lower concentrations the knock-down was negligible. The toxicity of DDT increased much more rapidly with increase in concentration than did that of the pyrethrins. Consequently below 0.7 milligram per milliliter, at which concentration the two materials had the same toxicity to these houseflies, the pyrethrins were more toxic, and above this concentration DDT was more toxic. The results are given in table 1. When the results were plotted on log-probability paper, it was found that the concentration required to give 50 per cent mortality was 1.65 milligrams per milliliter for pyrethrins and 0.95 milligram for DDT.

[1] E. R. Van Leeuwen assisted in the Peet-Grady tests.

Table 1.—Toxicity of DDT and pyrethrin sprays to adult houseflies, when tested by the turntable method.

MATERIAL	CONCENTRATION, PER MILLILITER OF SPRAY	MORTALITY IN 1 DAY
	Milligram	*Per Cent*
DDT	5.0	100
	2.5	100
	1.25	72
	1.0	63
	0.9	56
	0.8	27
	0.625	13
	0.50	3
Pyrethrins	0.5	13
	1.0	31
	2.0	58

Tests by the turntable method also showed that combinations of DDT with other insecticidal materials dissolved in kerosene formed effective fly sprays at very low concentrations. The other materials were chosen largely for their knock-down value. The results are given in table 2.

Table 2.—Toxicity of kerosene sprays containing mixtures of DDT with other insecticidal compounds.

CONCENTRATION OF DDT	OTHER COMPOUND AND CONCENTRATION[1]		KNOCK-DOWN IN 10 MINUTES	MORTALITY IN 1 DAY
Per Cent		*Per Cent*	*Per Cent*	*Per cent*
0.1	Pyrethrins	0.05	100	98
.1		.03	99	98
.05		.05	100	92
.1	Fenchyl thiocyanoacetate (Thanite)	2.0	100	100
.1	Beta-butoxy-beta'-thiocyanodiethyl ether (Lethane 384)	2.0	100	100
.1	None	—	10	81
None	Pyrethrins	.1	100	59
		.2	100	84

[1] Solids, weight per volume; liquids, volume per volume.

In tests by the Peet-Grady method when 12 milliliters were used per test, 0.2 per cent of DDT in deodorized kerosene, combined with 0.03 per cent of pyrethrins, 1 per cent of fenchyl thiocyanoacetate, or 1.5 per cent of the commercial grade of beta-butoxy-beta'-thiocyanodiethyl ether, knocked down and killed 100 per cent of the flies. DDT alone in deodorized kerosene caused less than 50 per cent knock-down in 10 minutes when 0.5 per cent or less was used. At 1 and 2 per cent much higher knock-down was obtained, but even at 2 per cent all the insects were not knocked down in 10 minutes.

As indicated by these preliminary tests, DDT forms very effective contact fly sprays when used in deodorized kerosene either alone or in conjunction with pyrethrins, beta-butoxy-beta'-thiocyanodiethyl ether, or fenchyl thiocyanoacetate.

DDT for the Control of Goat Lice

O. G. BABCOCK

Dipping tests with DDT for the control of three species of goat lice, two Mallophaga and one Anoplura, were conducted at Menard, Tex. Angora goats infested with the yellow louse, *Trichodectes hermsi* Kellogg and Nakayama, and the red lice, *T. caprae* Gurlt and *T. limbatus* Gervais, were dipped in 0.3 and 0.6 per cent of the chemical in a water emulsion. In every case all the lice were killed soon after hatching. The animals were examined at intervals for 26 days and no reinfestation developed.

In another test Angora goats infested with the blue *Linognathus stenopsis* (Burm.), as well as with yellow and red lice, were dipped in water emulsions in strengths of 0.3, 0.15, 0.07, and 0.04 per cent of DDT. All concentrations killed all red and yellow lice. All blue lice were killed with all concentrations except the 0.04 per cent DDT. The treated animals were examined at intervals for 25 days, and there was no evidence of a reinfestation. Tests were also made with DDT combined with wettable sulfur in the dips. These tests suggest that neither chemical the effectiveness of the other.

The limited tests conducted on Angora goats indicate that a single dipping in DDT may serve as an effective control for goat lice. The biting lice are more susceptible to this chemical than are the sucking lice. The DDT, even in concentrated emulsions, apparently had no effect upon the fiber or skin of the animals.

DDT as a Treatment for Fleas on Dogs[1]

ARTHUR W. LINDQUIST, A. H. MADDEN, and E. F. KNIPLING

Preliminary tests on the use of DDT in the control of the dog flea, *Ctenocephalides canis* (Curt.), the cat flea, *C. felis* (Bouché), and the sticktight flea, *Echidnophaga gallinacea* (Westw.), on dogs have been sufficiently promising to warrant the following brief report on the results obtained.

Powders containing DDT diluted to 4 or 5 per cent with pyrophyllite were dusted lightly over the animals and rubbed thoroughly into the hair, approximately 10 grams being required to treat a medium-sized dog. Eleven dogs moderately to heavily infested with dog and cat fleas and lightly infested with sticktight fleas were treated in these experiments.

The dog and cat fleas began to leave the host and drop to the ground within 10 to 15 minutes after the treatment. Some of the fleas died on the dogs, but most of them left the host as they became affected. Such fleas exhibited the typical reactions characteristic of insects affected by DDT, such as spasmodic twitching of the appendages. Specimens collected and held for observation died in from 3 to 5 hours. Sticktight fleas died on the host.

Treated dogs have been completely freed of fleas and protected from reinfestation for periods of 4 to 7 days, while untreated dogs used as checks have continued to harbor large flea populations. Check dogs treated on a comparative basis with derris powder (4.8 per cent rotenone) were protected for only 2 days.

None of the animals showed any ill effects from the treatment.

[1] Work done at the Orlando, Fla., laboratory.

DDT As a Roach Poison

A. W. MORRILL, JR.

Ten adults each of *Periplaneta americana* (L.) and *Blattella germanica* (L.) were fed for three weeks beginning July 22, 1943, upon a mixture containing 1 gram of DDT (100 per cent) to 100 grams of dog biscuit or mouse food as follows: (1) DDT and dog biscuit, (2) DDT and mouse food, (3) DDT in acetone (10 cc.) and dog biscuit, (4) DDT in acetone (10 cc.) and mouse food, and (5) DDT in acetone (10 cc.) and a 50–50 mixture of mouse food and dog biscuit with glycerin (10 cc.) and amyl acetate (5 cc.). In these tests all the roaches died except one *P. americana* that was given the last mixture. Similar numbers of these roaches held with untreated dog biscuits were alive, and about 35 nymphs of *B. germanica* had developed from eggs laid during the test period and were healthy.

On August 14, 1943, five adults of *Periplaneta americana* and *Blatella germanica* were placed in each of 20 jars containing a vial of water and a few untreated dog biscuits. Into each jar was introduced a wire basket containing a 50–50 mixture of dog biscuit and mouse food ground together to which DDT had been added at rates of 1 gram to 50, 100, 500, 1,000 grams of the food mixture, each rate being replicated five times. After 10 days, 1, 4, 7, and 20 roaches of the first species and 6, 14, 25, and 25 of the second were found alive in the respective mixtures. Twenty-five (all) adults of each species in check jars that were fed upon dog biscuits remained alive.

Efficacy of DDT as a Roach Poison[1]

JAMES B. GAHAN and E. F. KNIPLING

An extensive series of tests have been conducted at Orlando, Fla., to determine the practicability of using DDT against cockroaches. In laboratory tests the compound has been used in powder form only. In practical tests it has been applied also in sprays. The results that have been obtained against the American cockroach *Periplaneta americana* (L). and the German cockroach *Blattella germanica* (L.) are summarized in this note.

LABORATORY TESTS.—The first tests were conducted in small pens 14 inches square. When a dust containing 5 per cent of DDT in talc was applied in a band about an inch wide across the center of the pens and adults of both species were exposed continuously to the treatment, all insects were killed within 48 hours. In other tests in which only the American cockroach was used, DDT in concentration as low as 0.1 per cent was found to be completely effective within 96 hours.

Samples of 5 per cent DDT and undiluted sodium fluoride were compared as to effectiveness against the American cockroach in two pens each 10 feet square. All roaches that had been placed in the pen with DDT were on their backs within 48 hours, and 24 hours later they were dead, whereas only 60 per cent of those placed with the sodium fluoride were dead after 144 hours.

A more severe test was then conducted in which roaches were allowed to run once across a narrow band of DDT dust. Two tests were made with powders containing 5 per cent of DDT against

[1] Work was done at the Orlando, Fla., laboratory.

adults of both species. In this test the compound was much less effective against the German roach than against the American species. Mortalities of 30 and 40 per cent in 96 hours were obtained with the German roach, compared with 100 per cent in 48 and 72 hours with the American roach. When the concentration of active ingredient was reduced to 0.5 per cent and adult American roaches were allowed to run through the powder, one time a mortality of 83 per cent occurred in 72 hours. The compound was ineffective against this species at 0.1 per cent concentration. In similar tests with the American roach undiluted sodium fluoride required 72 hours to give a mortality of 50 per cent, and 144 hours to cause 80 per cent mortality. The kill was only 20 per cent in 144 hours when a 50 per cent mixture of sodium fluoride in talc was used.

PRACTICAL TESTS AT ARMY BASE.—Some practical tests were made in mess halls that were heavily infested with German roaches. A 5 per cent spray, made by dissolving DDT in an equal weight of cyclohexanone and mixing 1 gallon of this stock with 12.5 gallons of kerosene, was used in two buildings. A water emulsion containing 5 per cent of DDT, 15 per cent of xylene, and 5 per cent of *Triton NE* (an aralkyl polyether alcohol) was sprayed in a third building. Six buildings were dusted, four of them with 25 per cent of DDT mixed with talc and two others with 10 per cent of DDT in talc. The dusts were applied only to hiding places, the edges of rooms, and under stationary furniture, but the sprays were also applied to all wall surfaces that were made of wood or plaster board. The weight of DDT used per 100 square feet of floor space varied between 18 and 95 grams in the mess halls that were sprayed and between 19 and 29 grams in those that were dusted.

Large numbers of German cockroaches were killed by all these treatments. Almost instant results were obtained with the sprays, whereas delayed action was observed in the case of the dusts. In one building 2000 dead roaches were estimated to be on the floor within 30 minutes after spraying. The next morning the kitchen was so badly littered it was found inadvisable to use it until the insects were removed. The dusts were also highly toxic, and similar results were obtained with the 25 and 10 per cent mixtures. Twenty-four hours after treatment large numbers of dead and dying German cockroaches were found in all the rooms. In each of three buildings at least 4000 dead adults and large nymphs were seen on the floor.

Complete eradication of these pests has not been obtained in any of these buildings, but their populations have been decreased to such an extent that kitchen personnel consider the treatments satisfactory. The greatest reductions seem to have occurred in the buildings that were dusted. It is doubtful that 100 per cent control can be obtained in any of these buildings, unless the chemical is found to have a long residual effect when applied as a spray, because in Florida roaches can breed outdoors and there is a constant source of reinfestation. Dust deposits are unsightly to leave in mess halls for long periods of time, but spray residues applied in kerosene are practically invisible. Results obtained to date, however, indicate that sprays do not produce a residue sufficiently toxic to protect buildings from German roaches for more than a few days.

PRACTICAL TESTS IN A THEATER.—A theater near Orlando, which has had difficulty in controlling German roaches, was treated with a water emulsion containing 2.5 per cent of DDT, 5 per cent of xylene, and 0.1 per cent of *Triton NE*. One gallon of this preparation was applied to approximately 300 seats Fourteen days later living roaches were found, but the populations had been noticeably decreased.

PRACTICAL TEST IN A DAIRY.—On September 2, 1943, a dairy was sprayed with a mixture containing 2 per cent of DDT, 2 per cent of *Nopco 1216* (a sulfated sperm oil), and 10 per cent of acetone, at the rate of 18.5 grams of DDT per 100 square feet, in an effort to control the flies that were present. Upon examination 2 days later American roaches were found in large numbers on the floor of the building and the ground surrounding it. While no accurate determination could be made of the roaches killed, because the floors had been washed several times before the experiment was checked, 982 dead and dying adults and nymphs were counted. Two weeks after the spray was applied, the owners reported dead insects were still being found on the floor.

Toxicity of DDT to Bedbugs, Cockroaches, the Mexican Bean Beetle and Housefly Larvae

E. R. MCGOVRAN, H. H. RICHARDSON, and P. G. PIQUETT

BEDBUG SPRAY TESTS.—DDT in deodorized kerosene was found to be highly toxic to bedbugs, *Cimex lectularius* L. and *C. hemipterus* F., when applied directly as a contact spray by the turntable method. The bugs were confined in open glass dishes with filter paper on the bottom. At a concentration of 0.18 per cent (weight per volume) in deodorized kerosene DDT was as toxic as the same concentration of pyrethrins, although the lethal effect was not complete until 2 to 4 days after treatment as compared with 1 day for pyrethrum. The DDT sprays tested appeared to have little effect on bedbug eggs under the conditions of these tests.

ROACH SPRAY AND POWDER TESTS.—In preliminary tests by the pendulum method a deodorized-kerosene spray containing 2 per cent (w./v.) of DDT applied as a contact spray directly to the dorsal surface of German cockroaches, *Blattella germanica* L., was less effective than a deodorized-kerosene spray containing 0.4 per cent (w./v.) of pyrethrins. A similar DDT spray was ineffective against American cockroaches, *Periplaneta americana* L., by this method. When this 2 per cent DDT spray was tested by confining American roaches in a rising mist of spray, it showed appreciable toxicity but was less effective than a similar spray containing 0.2 per cent (w./v.) of pyrethrins. The roaches were not knocked down rapidly by the DDT sprays.

Insecticidal powders were tested against roaches in the laboratory by scattering weighed amounts uniformly over the floor of glass cylinders, which were lightly oiled to confine the insects placed in them. A proprietary powder containing 3 per cent of DDT caused mortalities of German roaches approximately equal to that obtained with a pyrethrum powder containing 0.66 per cent of pyrethrins. However, the DDT was less effective than the pyrethrum against American roaches.

In addition a dust containing 10 per cent of DDT in pyrophyllite was tested in comparison with a finely ground commercial grade (95 per cent) of

sodium fluoride. The DDT powder was less effective on both American and German roaches than the sodium fluoride, but on the basis of the amount of toxicant in each powder the DDT was more effective.

TESTS WITH MEXICAN BEAN BEETLES AND HOUSEFLY LARVAE.—DDT at 8 pounds to 100 gallons of water was applied in the laboratory to excised bean leaves by the spray-tower method. Acacia at 0.8 pound per 100 gallons was used as the wetting agent. As soon as the leaves had dried, they were placed in unsprayed cages and infested with 10 young fourth instars of the Mexican bean beetle, *Epilachna varivestis* Muls. The mortality in 6 days was 45 per cent. One pound of powdered derris root containing 4.8 per cent of rotenone in 100 gallons of water caused 67 per cent mortality in the same time.

Samples of housefly breeding media weighing approximately 23 grams each were treated with insecticide and infested with third-instar houseflies, *Musca domestica* L. The culture was then held until the adults emerged. In samples treated with 60 and 30 milligrams of DDT 88 and 77 per cent of the larvae died, as compared with 92 per cent when 60 milligrams of borax was added to a similar culture. Thiourea is much more toxic, for only 7.5 milligrams added to each 23 grams of media caused 92 per cent mortality.

Tests of DDT Against Ants and Termites

R. A. ST. GEORGE

Tests with DDT against ants, *Formica* sp., and subterranean termites, *Reticulitermes flavipes* Kol., were made at the Beltsville Research Center in the summer of 1943. Two types of commercial material were used, technically pure DDT and a mixture containing 5 per cent of DDT in an inert diluent.

The laboratory tests were made by applying the insecticide on the inside of a covered moist chamber (6 inches in diameter and 2 inches high) and allowing it to dry before releasing the insects. The technical material in 1 and 5 per cent strengths in acetone was applied as a wash; the 5 per cent commercial mixture was used undiluted as a dust and in 1 per cent aqueous solution as a spray. In the tests with termites a thin layer of moist earth was placed on the bottom of the container before the dust was applied. Only the dust was used against termites.

DDT was found to be toxic to ants in relatively low concentrations after a short period of time. They had considerable difficulty in walking within a few minutes after coming in contact with the residue of the 5 per cent DDT-acetone solution, and within a half hour some of them were unable to stand up. They died several hours later. An equal number of ants placed in an untreated chamber lived throughout the test. The 5 per cent mixture, when applied as a dust, acted a little more slowly, and the 1 per cent solution in acetone still more slowly, but both were effective.

When termites were confined in a chamber dusted lightly with the 5 per cent mixture, they succumbed within 2 days. In field tests, however, they avoided it wherever possible. A test was made on June 3, 1943, at 2 p.m. by treating the ground beneath each of three heavily infested logs, where large populations of termites were present. Following treatment the termites disappeared below ground, but after a a week a few had succeeded in reestablishing themselves in one of the logs.

Further field tests with termites were made by treating pieces of paper toweling, strips of Osnaburg fabric (1 by 5 inches), and small white pine plant markers with 1 or 5 per cent solutions of DDT in acetone. The paper and fabric were immersed for 2 minutes, but the wood was soaked for 18 hours. Three pieces of each material were used in each test. They were exposed out of doors on June 15 together with suitable untreated pieces as checks. The plant markers were buried half their length in the ground, while the other materials were laid on the surface beneath a board. Examinations were made on June 30, July 31, and October 30.

Because of severe drought termite surface activity was relatively light; consequently, the attack was not heavy.

All the paper-toweling checks were well attacked, as were some of the fabric checks. However, the termites merely tubed over the plant markers. Among the treated pieces, the termites attacked only the paper toweling. The pieces treated with the 1 per cent DDT had a medium attack, while those treated with the 5 per cent had only a trace of infestation. The termites built tubes over a portion of the treated fabrics and plant markers.

These meager data suggest that DDT may be toxic to subterranean termites and merit further test.

The Possible Utility of DDT for Insect-proofing Paper Bags

R. T. COTTON, A. I. BALZER, and H. D. YOUNG

The cadelle, the lesser grain border, and certain other insects cut through the walls of paper bags containing milled cereals and various dried food products. The impregnation of the papers from which these bags are made with suitable insect-proofing chemicals offers a means of preventing these beetles from boring into them.

Of a large number of chemicals tested, DDT has shown the greatest efficiency. In one series of tests disks of soft towel paper and kraft paper were impregnated with a 10 per cent solution of DDT (commercial grade) in acetone, and pasted over holes cut in the tops of tin salve boxes filled with a 4-4-1 mixture of graham flour, vitamin-enriched patent wheat flour, and rice polish. The paper on such boxes exposed for two months to the attack of the cadelle and the lesser grain borer suffered no damage, whereas none of the other chemicals tested afforded complete protection.

Although no commercial-scale tests with this material have been made, it may be found suitable for the impregnation of one of the plies of multi-wall paper bags or for incorporation into the coating liquor used in the preparation of coated kraft paper for making single-wall bags. The toxicity of this chemical in relation to the possible contamination of food products contained in the treated paper bags remains to be investigated.

Laboratory Tests of DDT Against Various Insect Pests

M. C. SWINGLE and E. L. MAYER

DDT has been tested against 20 species of insect pests at Sanford, Fla. Most of these tests were laboratory experiments designed to establish the fact of toxicity and the general effectiveness of the commercial dilutions received.

All the tests were made with three commercial samples—a dust containing 3 per cent of the active ingredient in an inert carrier, a spray material containing 5 per cent of the active ingredient and a wetting agent, and DDT concentrate. The 5 per cent DDT was used in all spraying tests and, in some cases, as a dust. All other concentrations tested were made by diluting the DDT concentrate with pyrophyllite.

The various tests will be discussed briefly under the insects used. Comparable tests of standard insecticides were run concurrently with these tests. In general, the results with DDT were equal, or far superior, to those of the standard insecticides, derris (4.8 per cent rotenone) and pyrethrum (1.2 per cent total pyrethrins).

American Cockroach, *Periplaneta americana* (L.).—One hundred per cent mortality was obtained in 18 hours when adults were confined on a surface treated with a 5 per cent dust, and within 48 hours when a 1 per cent dust was used. A 10 per cent dilution of sodium fluoride caused no mortality in 72 hours, and a 5 per cent dilution of pyrethrum killed only 65 per cent in 72 hours. When large nymphs were confined for 3 days on a deposit from a 1 per cent spray suspension of the DDT concentrate, 92 per cent mortality was obtained.

Bean Leaf Roller, *Urbanus proteus* (L.).—A 3 per cent dust on bean foliage killed 100 per cent of third instars within 2 days, with almost no feeding. The pyrethrum standard killed 96 per cent of the larvae in the same period. The spray applied at the rate of 4 pounds per 100 gallons of water gave excellent control of the first three instars in an outdoor garden.

A Blister Beetle, *Epicauta lemniscata* F.—A 3 per cent dust on Swiss chard leaves killed 100 per cent of adult beetles within 3 days. Undiluted barium fluosilicate killed 96 per cent of the beetles under similar conditions. A 4–100 suspension of the 5 per cent spray material on Swiss chard killed 0, 71, and 96 per cent of the beetles in 2, 4, and 6 days, respectively. A 4–100 suspension of undiluted cryolite killed only 25 and 75 per cent of the beetles in 4 and 6 days, respectively.

Cabbage Looper, *Autographa brassicae* (Riley).—A 3 per cent dust on collard leaves killed 100 per cent of fourth instars within 2 days. The pyrethrum standard killed 96 per cent of the larvae in the same time.

Colorado Potato Beetle, *Leptinotarsa decemlineata* (Say).—A spray, made at the rate of 1 pound of DDT concentrate per 100 gallons of water, caused complete mortality of all instars infesting potato plants in an outdoor garden.

Corn Leaf Hopper, *Peregrinus maidis* Ashm.—A 5 per cent dust caused 100 per cent mortality of large nymphs within 24 hours, when applied to the insects infesting a corn leaf. The pyrethrum standard diluted to 10 per cent in talc gave similar results.

Cowpea Weevil, *Callosobruchus maculatus* (F.).—A 3 per cent dust mixed with Crowder peas at the rate of 1 to 10,000 parts by weight gave complete control of adults confined in the peas within 2 days. The derris standard gave similar results in the same period.

Cross-Striped Cabbage Worm, *Evergestis rimosalis* (Guen.).—A 3 per cent dust applied to collard leaves caused 100 per cent mortality of fourth instars within 2 days. The pyrethrum standard gave similar results. At 4 pounds per 100 gallons the 5 per cent spray material caused 90 and 100 per cent mortality of third instars in 2 and 4 days, respectively. Derris at 8 pounds per 100 gallons killed 3 and 100 per cent of the larvae in 2 and 4 days.

Garden Flea Hopper, *Halticus bracteatus* (Say).—A 3 per cent dust gave excellent control in weekly applications to small celery plants in an outdoor plot. A commercial pyrethrum dust was relatively ineffective in semiweekly applications. A suspension of 8 pounds of the 5 per cent DDT in 100 gallons of water also gave excellent control.

Harlequin Bug, *Murgantia histrionica* (Hahn).—A 1 per cent DDT dust killed 90 per cent of adults within 2 days. Four other concentrations ranging from 3 to 100 per cent, as well as the undiluted pyrethrum standard, gave about the same results.

Imported Cabbage Worm, *Pieris rapae* (L.).—A 5 per cent dust on collard leaves killed 100 per cent of fourth instars within 2 days. The derris standard gave the same results.

A Looper, *Autographa rogationis* (Guen.).—Dust dilutions as low as 1 per cent killed from 90 to 100 per cent of fourth instars within 2 days, and 0.6 per cent dust killed 100 per cent in 3 days. A derris dust, diluted to contain 0.96 per cent of rotenone, killed 89 per cent of the larvae within 3 days. An 8–100 suspension of the 5 per cent DDT applied to collard plants killed 33, 85, and 96 per cent of fourth instars in 2, 4, and 6 days, respectively. A 4–100 spray killed only 62 per cent of the larvae in 6 days. Lead arsenate at 8–100 caused 100 per cent mortality within 4 days, and derris at 4–100 killed 46 per cent within 6 days.

Melonworm, *Diaphania hyalinata* (L.).—Various concentrations of DDT dust down to 0.6 per cent killed from 90 to 100 per cent of fourth instars on pumpkin foliage within 2 days. A derris dust, diluted to contain 0.96 per cent of rotenone, killed only 36 per cent in 2 days. An 8–100 suspension of the 5 per cent DDT, applied to pumpkin plants, killed 55 and 100 per cent of fourth instars in 2 and 4 days respectively. A 4–100 suspension gave equally good results. Derris at 8 pounds per 100 gallons caused only 77 per cent mortality in 6 days.

Pickleworm, *Diaphania nitidalis* (Stoll).—All dilutions of DDT dust down to 0.6 per cent caused 100 per cent mortality of fourth instars on pumpkin foliage. Derris dust containing 0.96 per cent of rotenone killed only 24 per cent in 2 days. An 8–100 DDT spray suspension applied to pumpkin foliage caused 100 per cent mortality in 2 days and a 4–100 suspension in 4 days. Derris at 4 pounds per 100 gallons also killed 100 per cent of the larvae in 4 days.

Red Flour Beetle, *Tribolium castaneum* (Hbst.).—A 3 per cent dust mixed with wheat at a dilution of 1 to 10,000 parts by weight caused 100 per cent mortality of adult beetles confined in the treated grain for 2 days.

Rice Weevil, *Sitophylus oryza* (L.).—A 3 per cent dust mixed with wheat at 1 to 10,000 parts by weight caused 50 and 82 per cent mortality of adult weevils in 3 and 5 days, respectively. Derris at 1–200 killed

36 and 100 per cent of the weevils in 4 and 7 days, respectively.

Southern Armyworm, *Prodenia eridania* (Cram.).—A 3 per cent dust on collard leaves killed 100 per cent of fourth instars within 2 days. Pyrethrum killed only 48 per cent in the same time. An 8–100 suspension of the 5 per cent DDT, applied as a spray to collard plants, also caused 100 per cent mortality within 2 days. This foliage was equally toxic to larvae 8 days after application of the spray. Undiluted lead arsenate at 8–100 killed 97 per cent of the larvae in 2 days.

Spirea Aphid, *Aphis spireacola* Patch.—A 3 per cent dust killed all stages of this species on young orange, but did not kill so quickly as a 0.25 per cent nicotine sulfate spray.

Squash Bug, *Anasa tristis* (Deg.).—A 3 per cent dust applied to first and fourth instars on pumpkin foliage caused 100 per cent mortality in 2 days. The pyrethrum standard gave the same results against fourth instars.

Termites, *Reticulitermes* sp.—A 3 per cent dust mixed with sand at 1 to 10,000 parts by weight caused no mortality within 2 days of adult termites placed on the surface of the treated sand. However, the treatment repelled the termites and prevented their entrance into the sand. In 5 days 97 per cent were dead, but this mortality must have been caused by excessive exposure to the air.

Phytotoxicity Tests.—A spray suspension of 8 pounds of 5 per cent DDT per 100 gallons of water, in two applications 7 days apart, caused no injury to young bean, pea, pumpkin, swiss chard, and collard plants. Two applications of a 1 per cent suspension of the DDT concentrate also caused no injury to young bean, pumpkin, swiss chard, potato, and collard plants.

Tests with DDT on the More Important Cotton Insects

E. E. IVY[1]

Cage and laboratory tests were conducted at Waco, Tex., in 1943 with 2 per cent DDT-pryophyllite dust against the bollworm, *Heliothis armigera* (Hbn.), the boll weevil, *Anthonomus grandis* Boh., the cotton leafworm, *Alabama argillacea* (Hbn.), and the cotton aphid, *Aphis gossypii* Glov. DDT was found to be very effective against the bollworm, but comparatively ineffective against the other insects

The procedure described by Moreland et al. (1941) was used in the cage tests, except that the cotton plants were dusted in a dusting chamber (Ivy, 1943) in which the dosage was accurately controlled. The dusting chamber was also used to dust sheets of blotting paper on which bollworm larvae were placed for various periods. A dusting tower similar to that described by Waters (1943) was used for the aphid tests and in the laboratory tests in which bollworm larvae were dusted.

In one series of cage tests a 2 per cent DDT-pyrophyllite mixture, used at 32 pounds per acre, caused an average net mortality of 96 per cent of third-instar bollworms, as compared with basic copper arsenate-sulfur (1:1) 86 per cent, cryolite (92.1 per cent sodium fluoaluminate)-sulfur (1:1) 77 per cent, calcium arsenate-sulfur (1:1) 62 per cent, all at 16 pounds per acre. In another series of cage tests the DDT produced 97 per cent average net mortality of bollworms at 32 pounds, 82 per cent at 16 pounds, and 63 per cent at 8 pounds per acre. Calcium arsenate at 8 pounds per acre produced 62 per cent mortality.

DDT acts both as a stomach poison and as a contact insecticide against the bollworm, but it is believed that its effect as a contact insecticide is the more important. Bollworms were readily killed by exposure to dust clouds of this material. Following a 30-second exposure, 40 per cent kill was obtained with fifth instars, 90 per cent with fourth instars, and 100 per cent with third instars. Bollworm larvae were also killed when placed on large sheets of blotting paper that had been dusted at the rate of 32 pounds per acre. After larvae had walked on the dust for 1 to 10 minutes, they were observed to thrash their heads about, regurgitate, and made jerky, spasmodic movements. Complete kill of fourth and fifth instars was obtained following 1 hour and 40 minutes' exposure to the dusted paper. All third instars were killed after 10 minutes. Bollworm larvae fed a dusted leaf sandwich consumed a lethal dose after 2 to 4 days' exposure.

A water suspension of 2 per cent DDT-pyrophyllite killed bollworms when placed on the dorsum with a pipette. The quantity of DDT applied to each bollworm was regulated by varying the concentration of the suspension. The median lethal dose of DDT applied in this manner to 240 fifth instars was found to be 0.299 milligram per gram of body weight.

DDT-pyrophyllite dust applied at the rate of 32 pounds per acre was comparatively ineffective against the cotton leafworm (35.5 per cent net mortality) and the boll weevil (18.5 per cent net mortality). DDT dust was found to have little effect (15.4 per cent mortality) on the cotton aphid in laboratory tests. Two per cent nicotine dusts produced 81 per cent mortality in these tests.

[1] In cooperation with the Texas Agricultural Experiment Station.

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DDT and Other Insecticides for the Say Stinkbug and the Tarnished Plant Bug

O. A. HILLS

During the course of laboratory experiments on new insecticides at Phoenix, Ariz., a dust mixture containing DDT was tested against adults of the Say stinkbug, *Chlorochroa sayi* (Stål). In each test 10 bugs were placed in a small cylindrical screen cage containing a branch of the host plant, wheelscale saltbrush, *Atriplex elegans* (Moq.), which was dusted by use of a small hand duster. The results of two experiments in which DDT was used as given in table 1 show that the 10 per cent strength killed a high percentage of the stinkbugs but its action was rather slow, the mortality not being complete until

Table 1.—Mortality of adults of the Say stinkbug in laboratory tests with new insecticides.

Insecticide	Number of Individuals Tested	Per Cent Mortality After— 1 day	2 days	3 days	4 days	5 days	6 days
Experiment 1, with 10 replicates, August 17–23							
DDT (10 per cent)	100	14	53	—	86	—	89
Dinitro-o-cresol (1 per cent)	100	89	90	—	92	—	92
2-Chlorofluorene (20 per cent)	99	5	12	—	23	—	47
None	100	1	7	—	15	—	30
Difference required for significance (odds 19 to 1)	—	16	19	—	18	—	18
Experiment 2, with 9 replicates, September 1–6							
Dinitro-o-cyclohexylphenol (1 per cent)	90	94	97	98	98	98	—
DDT (10 per cent)	90	13	43	75	93	95	—
Dinitro-o-cresol (1 per cent)	93	88	90	90	90	90	—
None	89	1	2	6	9	10	—
Difference required for significance (odds 19 to 1)	—	12	—	16	—	15	—

4 to 6 days after application. However, a definite effect of the DDT on the insects could be noted after 24 hours. They became agitated, waving the legs about with a quick jerky motion and keeping their antennae in constant vibration. Even after the insects could no longer move about and were on their backs on the floor of the cage, the antennae were still in constant motion.

In similar tests with the 10 per cent strength of DDT on 100 nymphs and 100 adults of the tarnished plant bug, *Lygus oblineatus* (Say), 96 and 99 per cent of the nymphs and adults, respectively, were killed in 24 hours, and all were killed in 48 hours.

Tests with DDT Against Pentatomids, Mirids, the Bollworm, and the Cotton Aphid

W. A. Stevenson, Louis Sheets, and J. M. Breazeale

Cage tests were conducted at Mesa, Ariz., in 1943 using a 2 per cent DDT-pyrophyllite dust against the pentatomids *Euschistus impictiventris* Stål and *Chlorochroa sayi* Stål, the mirids *Lygus* spp. and *Creontiades femoralis* Van D., the bollworm, *Heliothis armigera* (Hbn.), and at Marama, Ariz., against the cotton aphid, *Aphis gossypii* Glov. Screen cages 4 by 4 by 4 feet were placed over cotton plants on which the insects had been released, and the plants were then thoroughly dusted with a rotary hand gun. Equal numbers of insects were used as untreated checks. In one test the plants were wet from rain when dusted, but in no case was any injury caused.

The results for the pentatomids and the mirids are summarized in table 1.

Two cage tests were conducted with bollworms. In one test the mortality was 100 per cent in 46 hours, while in the other it was very poor.

In a small plot of cotton dusted with 2 per cent DDT on August 26, temperature 87° F., 41 per cent of the cotton aphids were dead after 48 hours. A dust containing 2 per cent of free nicotine applied at the same time gave 76 per cent mortality. In another plot dusted on September 3, temperature 82° F., the aphid mortality caused by DDT was 5 per cent, as compared with 86 per cent from nicotine.

DDT for Control of Thrips on Cotton

Ivan Shiller and C. A. Richmond[1]

Preliminary tests were conducted in the lower Rio Grande Valley of Texas during April 1943 comparing dust containing 3 per cent of DDT in pyrophyllite with a sulfur dust containing 2 per cent of

[1] In cooperation with the Texas Agricultural Experiment Station.

Table 1.—Mortality of pentatomids and mirids following treatment with DDT.

Species	Number of Insects	Number of Insects Dead After— 24 hours Treated	24 hours Untreated	48 hours Treated	48 hours Untreated	96 hours Treated	96 hours Untreated
Euschistus impictiventris	60	30	2	47	8	60	12[1]
Chlorochroa sayi	29	3	0	24	2	29	3
Creontiades femoralis	20	20	0	—	—	—	—
Lygus sp.	20	20	0	—	—	—	—

[1] Eight were in a cage previously used for a DDT test.

Table 1.—Effectiveness of dusts containing DDT-pyrophyllite and dinitro-ortho-cyclohexylphenol-sulfur against thrips on cotton.

Date of Application	Pounds per Acre	Average Thrips Before Treatment	Hours After Treatment	Number of Thrips per Plant		
				DDT-pyrophyllite	Dinitro-ortho-cyclohexyl-phenol-sulfur	Check, untreated
April 19	15	84.2	8	20.1	58.0	—
			32	25	100	130
23	20	144.4	8	5.6	82.0	125
			56	4.7	36.8	85.5

dinitro-ortho-cyclohexylphenol for control of *Thrips tabaci* Lind. and *Frankliniella fusca* (Hinds) on cotton. The plants contained 6 to 10 leaves and were so heavily infested in fields adjacent to winter vegetables that several hundred acres of cotton had to be replanted. *T. tabaci* was the predominant species. The population was determined before and after treatment by cutting a few plants at ground level in several locations in each plot, placing them in a paper bag, and then shaking them over a laboratory table and counting the dislodged thrips. Two tests were conducted in 1/10-acre plots located within a 50-acre field. Only one plot of each treatment was used in each test. One application of each mixture was made with a rotary hand gun in the morning while the plants were moist with dew. The rate of application and the average number of thrips per plant are shown in table 1.

Tests with DDT Against a Stinkbug and the Cotton Leafworm

J. C. CLARK[1]

Cage tests were conducted at Presidio, Tex., in 1943 with DDT-pyrophyllite against the stinkbug *Chlorochroa ligata* (Say), commonly known as the conchuela in the Southwest. Screen cages 4 by 4 by 4 feet were placed over cotton plants. Cloth bottoms were placed on the ground around the plants to facilitate recovery of the dead insects. Adults were released in the morning, and the plants dusted the following day with a rotary hand gun. The dosage used was not determined, but sufficient material was used to give a good coverage of the plants. The dead insects were removed daily for five days, when the tests were discontinued. The results with DDT and paris green-sulfur mixture used for comparison are given in table 1.

[1] In cooperation with the Texas Agricultural Experiment Station.

Table 1.—Effectiveness of DDT against *Chlorochroa ligata*.

Insecticide	Number of Tests	Number of Insects Used	Per Cent Mortality*
DDT 5 per cent	6	222	80
DDT 2 per cent	13	421	66
Paris green 7.5, sulfur 92.5 per cent	4	135	19
Untreated check	—	—	15

* Determined by Abbott's formula.

In a field test against the cotton leafworm, *Alabama argillacea* (Hbn.), using a 2 per cent DDT-pyrophyllite dust at the rates of 5 and 10 pounds per acre, no mortality was observed after six days.

Tests with DDT Against the Boll Weevil

GEORGE L. SMITH

Cage tests using 1 and 2 per cent DDT-pyrophyllite mixtures were conducted against the boll weevil, *Anthonomus grandis* Boh., at Tallulah, La., during July and August 1943. The weevils were released on the caged cotton plants, which were then thoroughly dusted with a hand gun. Based on 24 replications with a total of 776 weevils, the average net mortality after 96 hours, calculated by Abbott's formula, was 16 per cent with each mixture, as compared with 77 per cent when calcium arsenate was used.

Tests of DDT Dust Against the Sugarcane Borer, the Yellow Sugarcane Aphid, and the Argentine Ant

J. W. INGRAM

Sugarcane Borer.—A DDT-pyrophyllite (50–50) mixture was tested at Houma, La., against the sugarcane borer, *Diatraea saccharalis* (F.), during September and October 1943 in a 5 by 5 latin-square experiment on sugarcane of the variety C. P. 34/120 that had been planted early in August. This cane was similar in size and growth to that prevailing in the spring at the time of dusting for control of first-generation borers.

The DDT mixture was compared with synthetic cryolite, synthetic cryolite-sodium fluosilicate (90–10), dimethylacridan-pyrophyllite (67–33), and an untreated check. All materials were applied at the rate of 8 pounds per acre per application on September 10 and 27 and on October 1 and 8. The second application was delayed by continued rain until

September 27. The plots were 5 rows wide and 72 feet long with 3-row side buffers and 30-foot end buffers.

On October 29 all dead hearts were examined on the three middle rows of each plot with the exception of 3 feet at each end. The results given in table 1 indicate the DDT-pyrophyllite gave a lower degree of borer control than did synthetic cryolite, although not significantly so.

Table 1.—Live sugarcane borers surviving per plot in latin-square insecticide experiment.

Treatment	Average Number of Borers per Plot
Check, untreated	7.0
Dimethylacridan-pyrophyllite	3.2
DDT-pryophyllite	1.8
Synthetic cryolite-sodium fluosilicate	0.2
Synthetic cryolite	0.2
Difference required for significance:	
At odds of 19:1	2.6
At odds 99:1	3.6

YELLOW SUGARCANE APHID.—On October 4 and 11, in each instance 3 days after a dusting, the sugarcane borer plots were examined to determine the effect of DDT on the abundance of the yellow sugarcane aphid, *Sipha flava* Forbes. This aphid, which feeds almost entirely on the under side of the sugarcane leaves, has at times increased to injurious numbers following dusting with synthetic cryolite. The number of aphid-infested leaves was determined on 15 feet in each of the 2 rows (about 80 plants) per plot on October 4 and in 3 rows (about 120 plants) per plot on October 11.

As shown in table 2, the number of aphid-infested leaves in the DDT plots was about six times as great as in the undusted check plots on both dates. More than twice as many aphid-infested leaves were found in the DDT plots as in the synthetic cryolite plots.

The DDT plots could readily be recognized in the field by the unusually large number of yellowing and reddening leaves resulting from yellow aphid injury. Predators were observed in good numbers attacking the aphids in the untreated plots, some were observed in the synthetic cryolite plots, but none were seen in the DDT plots. It is apparent that the great increase in aphids resulting from the use of DDT would be a serious drawback to its use in control of the sugarcane borer.

Table 2.—Effect of DDT-pyrophyllite dust on *Sipha flava* abundance in replicated borer control experiment.

Treatment	Average Number of Infested Leaves	
	Oct. 4	Oct. 11
DDT-pyrophyllite	39.2	101.8
Synthetic cryolite	—	40.2
Check, untreated	6.0	17.8

ARGENTINE ANT.—A thin line of DDT was placed across an Argentine ant, *Iridomyrmax humilis* Mayr, trail in a greenhouse, but the ants did not detour to avoid crossing it. They apparently suffered no ill effects from contact with it, but this might have been due to the slow action of this insecticide.

In another case ants of this species had for several years nested in unusually large numbers between a gate post and a plank nailed to it. Both immediate-action ant-poison syrup and boiling water were poured into the nest several times, but the ants were not dislodged. On the afternoon of October 21 several puffs of undiluted DDT dust were blown into this nest with a plunger-type hand gun. By the next afternoon no ants were observed on the post or gate, having either abandoned their nest or having all been killed. No ants were observed on the post or on the gate up to October 30.

DDT Against the White-fringed Beetle and the Velvetbean Caterpillar

HIRAM C. YOUNG

Insectary and field-plot tests of DDT were conducted against the adults of one species of white-fringed beetles, *Pantomorus leucoloma* (Boh.), and larvae of the velvetbean caterpillar, *Anticarsia gemmatilis* (Hbn.), at Florala, Ala., during August and September 1943. It was the most potent insecticide ever tested against adult white-fringed beetles.

WHITE-FRINGED BEETLE.—In the insectary tests against the white-fringed beetle cotton and peanut foliage held in 2-ounce wide-mouth bottles embedded in small flowerpots was treated in a settling chamber with dusts containing different percentages of DDT

Table 1.—Results of cage tests of DDT dusts as stomach poisons against white-fringed beetle adults.

Treatment	Average Mortality, Per Cent			
	24 hours	48 hours	72 hours	96 hours
Tests on Cotton Foliage				
DDT:				
0.5 per cent	0	0	6	8
1.0 per cent	0	0	12	28 (12)[1]
2.5 per cent	16	74	94	96 (4)
5.0 per cent	18	84	96	100
Synthetic cryolite	0	4	12	14
Calcium arsenate	10	27	53	69
Untreated	2	2	8	12
Tests on Peanut Foliage				
DDT:				
0.5 per cent	4	26	52	70 (6)
1.0 per cent	6	34	68	72 (4)
2.5 per cent	16	100	100	100
5.0 per cent	35	100	100	100
Synthetic cryolite	12	53	73	92
Untreated	2	4	4	4

[1] Numbers in parentheses indicate additional percentage stupefied beyond recovery at end of test.

in pyrophyllite. After the dusts had been allowed to settle for 2 minutes, newly collected adult beetles were confined on the treated foliage in screen cages 9 inches high and 5¼ inches in diameter. A total of about 50 beetles in 5 cages was used in each treatment. The results obtained with the lower concentrations tested are shown in table 1.

Table 2.—Results of cage tests of DDT sprays as stomach poisons against white-fringed beetle adults.

Insecticide in 100 Gallons of Water	Average Mortality, Per Cent			
	24 hours	48 hours	72 hours	96 hours
Tests on Cotton Foliage				
DDT:				
0.125 lb.	2	47	65	76 (12)[1]
.25 lb.	0	65	100	100
.50 lb.	6	69	90	100
1.00 lb.	20	90	100	100
Synthetic cryolite, 12.5 lb.	0	6	22	56
Untreated	0	2	4	6
Tests on Peanut Foliage				
DDT:				
0.125 lb.	6	69	94	100
.25 lb.	10	80	98	98 (2)
.50 lb.	10	84	98	98 (2)
1.00 lb.	31	84	100	100
Synthetic cryolite, 12.5 lb.	13	27	50	77
Untreated	0	0	2	2

[1] Numbers in parentheses indicate additional percentage stupefied beyond recovery at end of test.

Sprays containing different percentages of DDT and 0.5 per cent of a spreading agent were applied outside the insectary with a hand sprayer to cotton and peanut foliage held in wide-mouth bottles until the spray dripped from the foliage. Beetles were confined on the sprayed foliage in the manner described for dusts. The results obtained with the lower concentrations tested are given in table 2.

Table 3.—Results of laboratory cage tests of DDT dusts and sprays as contact poisons against white-fringed beetle adults.

Treatment	Average Mortality Per Cent			
	24 hours	48 hours	72 hours	96 hours
Pyrophyllite dust	4	6	8	8
Synthetic cryolite dust	0	0	2	2
Calcium arsenate dust	2	4	6	10
DDT, 2.5 per cent dust	11	26	45	45
Water spray	4	6	8	8
Synthetic cryolite, 12.5 lb. per 100 gal. water	0	6	11	13
Calcium arsenate, 12.5 lb. per 100 gal. water	6	8	12	14
DDT, 0.5 lb. per 100 gal. water	46	78	91	93
Untreated	0	2	2	2

The results of some of the laboratory tests to determine the effectiveness of DDT as a contact insecticide are shown in table 3. In these tests the white-fringed beetles were treated in cages and then transferred to untreated foliage in clean cages.

In one test 1 and 5 per cent DDT dusts were heavily applied to a paper surface in the bottom of five flat cages. Nine or ten beetles were placed on the dusted surface in each cage, allowed to remain in the cages for one hour, then removed to observation cages and given untreated peanut foliage. Most of the beetles were in contact with the treated surface only for the few minutes it took them to crawl to and up the sides of the cage. The 5 per cent dust caused an average mortality of 88 per cent, and the 1 per cent dust 6 per cent, at the end of 4 days. In the untreated check cages the mortality averaged 2 per cent.

To determine how long DDT would remain ef-

Table 4.—Net mortality of adult white-fringed beetles fed on peanut foliage at different intervals after it was dusted or sprayed with DDT in field plots.

Treatment	Application	Percentage Net Mortality After—					
						15 days	
		0 days	2 days	4 days	8 days	Entire foliage	Old foliage
Dust, DDT 2.5 per cent in pyrophyllite	Heavy	100	98	100	−4	—	—
Sprays:							
DDT 0.5 lb., raw linseed oil 3 pints, water 100 gal.	Heavy	100	92	78	57	7	56
DDT 0.08 lb., raw linseed oil 0.4 lb., triethanolamine 0.04 lb., water to make 1 gal.	Very heavy	100	100	100	77	59	98
DDT 0.8 lb. in 0.4 pint of acetone, raw linseed oil 0.4 lb., triethanolamine 0.14 lb., water to make 1 gal.	Very light	100	92	56	18	46	—
Untreated	—	4	2	6	16	8	8

fective under field conditions, tests were made in which dusts and sprays were applied to young, rapidly growing peanut plants. Five foliage samples were taken from each of the treated plots at intervals following treatment, and 10 beetles were placed on each in insectary cages. Owing to the rapid growth of the plants two types of foliage were tested after 15 days' exposure, shoots bearing both treated foliage and new growth, and shoots from which the untreated growth had been removed. The results of one test are shown in table 4.

VELVETBEAN CATERPILLAR.—In a laboratory cage test of a 2.5 per cent DDT-pyrophyllite dust and a 9:1 cryolite-wheat flour dust against half-grown velvetbean caterpillars on peanut foliage, 48 hours were required for DDT and 96 hours for cryolite to cause 100 per cent mortality.

A field plot of velvetbeans was treated twice to control the velvetbean caterpillar with a spray containing 0.5 pound of DDT and 3 pints of raw linseed oil per 100 gallons of water. The first application was made on September 14 at the rate of 58 gallons per acre and gave good control, as evidenced by the fact that no further defoliation occurred in the treated plot, whereas the plants in the adjoining areas were completely defoliated by September 22. The second application was made on September 24 to protect the new foliage from the hordes of caterpillars that were moving in from the surrounding untreated area. Although the caterpillars were active for several weeks after the second application, the foliage in the treated plot was not damaged.

EFFECT OF DDT ON PLANT FOLIAGE.—DDT was tested for injury to the foliage of 17 species of plants, as a 50–50 DDT-pyrophyllite dust, and as a spray containing 0.5 pound of DDT and 3 pints of raw linseed oil per 100 gallons of water. No rain occurred for 10 days or more after the applications, and no foliage injury was observed on any of these plants, which included upland cotton, cowpea, peanut, soybean, tomato, velvetbean, and 11 species of herbaceous flowers and weeds.

DDT to Control the Tobacco Moth and the Cigarette Beetle

JOSEPH N. TENHET

In the search for a substitute for pyrethrum in the control of the tobacco moth, *Ephestia elutella* (Hbn.), and the cigarette beetle, *Lasioderma serricorne* (F.), in open-type warehouses, DDT has given promising results in laboratory tests.

The tests were made in a modified Peet-Grady chamber, which was constructed of glass and measured 2 by 2 by 5 feet. Fifty newly emerged adults, 25 of each species, were used in each test, which was replicated 8 times. The insects were reared in the laboratory under controlled temperature and humidity, were selected at random, and were as uniform as could be expected of any group of insects.

The DDT was dissolved in a light volatile highly refined oil of the kerosene type and used as a concentrated spray at the rate of 75 cubic centimeters per 1,000 cubic feet.

Table 2.—Effect of the exposure of tobacco moths and cigarette beetles in groups of 25 in wire-gauze cages sprayed with 5 per cent of DDT in oil.

Insects	Interval Between Spraying of Cage and Exposure of Insects	Time Insects Were Exposed	Mortality	
			In sprayed cage	In Unsprayed cage
	Days	*Days*	*Per Cent*	*Per Cent*
Cigarette beetle adults	0.2	2	100	24
	9	3	96	0
	37	3	92	8
Tobacco moth adults	2	0.2	72[1]	4[1]
	2	3	100	4
	9	3	100	0
	37	3	76	8
Tobacco moth larvae	14	15	20	32

[1] Per cent moribund after 24 hours.

In each test the floor of the chamber was covered with clean blotting paper, the insects were introduced (free), and the insecticide was atomized into the chamber at 30 pounds' pressure. After 15 minutes' exposure, the chamber was air-washed by means of an exhaust fan for 15 minutes. The test insects were then placed in clean wire-gauze cages for observation, the tobacco moths for 3 days and the cigarette beetles for 5 days. Records were maintained of the knock-down, the mortality, and, for the tobacco moths, the number of eggs deposited.

The results with DDT in comparison with those obtained from a standard pyrethrum-oil spray are summarized in table 1.

All insects that could not fly or crawl up the side of the cage at the end of 24 hours were considered

Table 1.—Relative effectiveness of oil sprays containing DDT and pyrethrum against the tobacco moth and the cigarette beetle.

Insecticide in Oil Spray	Tobacco Moths			Cigarette Beetles	
	Moribund after 24 hours	Mortality after 3 days	Eggs deposited in 3 days	Moribund after 24 hours	Mortality after 5 days
	Per cent	*Per cent*	*Number*	*Per cent*	*Per cent*
DDT, 3 per cent	90	94	1298	28	44
DDT, 5 per cent	98	100	1039	50	66
Pyrethrum extract, 0.2 per cent total pyrethrins	95	96	1202	24	36
None, unsprayed	4	16	380	2	19

moribund. Tobacco moths that were still moribund after 3 days and cigarette beetles after 5 days were considered as dead. In none of the cages sprayed with DDT was there any decrease in the number of moribund insects during the period of observation. This would seem to indicate that the paralyzed insects seldom, if ever, recovered. The normal mortality of the unsprayed insects, however, increased sharply after the first 24 hours.

The data presented in table 1 show that DDT is slightly more toxic to stored-tobacco insects than is pyrethrum.

No deleterious effects were noted from the handling of DDT or from the breathing of the atomized spray.

To obtain information upon the residual effect of DDT, wire-gauze cages were sprayed with an oil containing 5 per cent of DDT as previously described. At various intervals after the cages were thoroughly dry, tobacco moths and cigarette beetles were confined in them for different lengths of time. Results of these unreplicated tests are presented in table 2. With a short confinement in these cages (0.2 day) the percentage of moribund tobacco moths was only moderately high 9 days after spraying, whereas a prolonged confinement caused 100 per cent mortality after 9 days and 76 per cent even after 37 days. However, mature larvae of the tobacco moth were not affected after more than 2 weeks' exposure.

Cage Tests with DDT Against Certain Insects Affecting Tobacco

F. S. CHAMBERLIN

Complete mortality of 100 adults of the tobacco flea beetle, *Epitrix hirtipennis* Melsh., was obtained in 24 hours with a 5 per cent DDT dust mixture. The insects were confined to small tobacco plants under 4 lantern globes, and the dust was applied by means of a precision duster.

Tests on the tobacco hornworm, *Protoparce sexta* (Johan.), were conducted on growing cigar-tobacco plants within cloth-covered cages 5 feet high and 26 by 24 inches in area. Ten second and third instars were used in each cage, and the insecticide was applied with a small puff-type hand duster at the rate of 15 to 20 pounds per acre. Complete mortality of 70 larvae was obtained in 48 hours with a 3 per cent DDT dust. Comparable larvae that were not treated with insecticides were all alive after 5 days, whereas all of 50 larvae treated with lead arsenate were dead in 48 hours. The larvae consumed very little of the foliage dusted with DDT. These tests indicate that DDT is very toxic to the hornworm. However, results obtained with this insect within cages may be deceptive and not indicate the true status of a poison under field conditions.

A 3 per cent DDT dust was applied to pea and okra plants infested with the southern green stinkbug, *Nezara viridula* (L.), a minor pest of tobacco, in cages 12 by 16 by 16 inches. Approximately 40 adults were used in each cage. Comparable untreated lots were observed. In the first tests the mortality after 3 days was 86 and 54 per cent in the dusted and undusted lots, respectively. In two later tests the mortality of the adult stinkbugs 5 days after being dusted with the 3 per cent DDT was 75 and 72 per cent, respectively, whereas that of undusted stinkbugs was 28 and 38 per cent.

Laboratory Cage Tests of DDT in Grasshopper Baits

E. J. HINMAN

Cage tests were conducted to compare the toxicity of DDT with that of sodium fluosilicate in grasshopper baits. Wheat bran was used as carrier in all the tests. In the sodium fluosilicate bait and in two of the DDT baits the poison in dry powder form was thoroughly mixed with the dry bran. Water was added to make a moist mash just before the baits were placed in the cages. The third DDT bait was prepared by dissolving the required amount of DDT concentrate in enough acetone to moisten the bran The bran and solution were mixed until all particles of bran appeared moist. The mixture was spread out thinly in a shallow pan and allowed to stand overnight. In the morning no odor of acetone could be detected. This bait was also moistened with water just before it was used.

The grasshoppers used were adults collected in the field. *Melanoplus mexicanus mexicanus* (Sauss.) was the most abundant species, but small numbers of *M. bivittatus* (Say) and *M. femur-rubrum* (Deg.) were also present. Thirty or more grasshoppers were used in each cage. They were held overnight without food, and in the morning the fresh baits were placed singly in each of eight cages on paper cards. The grasshoppers appeared to feed on all the baits alike. The results are shown in table 1.

Table 1.—Results of comparative cage tests of DDT and sodium fluosilicate baits against grasshoppers.

Insecticide in 100 Lbs. of Bran	Average Mortality After—	
	1 day	3 days
	Per Cent	*Per Cent*
Sodium fluosilicate, 4 lbs.	78	100
DDT, 4 lbs.	33	57
DDT, 3 lbs.	24	62
DDT, 4 lbs. in acetone	35	83
Check, no bait	6	16

Least significant difference (19:1 odds), 8.4 per cent.

All the baits prepared with DDT were definitely toxic to grasshoppers but were inferior to the sodium fluosilicate bait. The mortalities caused by 3 and 4 pounds of dry DDT per 100 pounds of bran were not significantly different but those caused by DDT dissolved in acetone before being mixed with bran were significantly greater. This shows that a more effective bait many result from more even and intimate distribution of DDT in the carrier.

Efficiency of DDT as a Dust and in Bait for Grasshopper Control

C. C. WILSON

Field trials were conducted with DDT as a dust and in moist bran baits during August 1943 against grasshopper infestations consisting of 10 to 30 adult

Table 1.—Comparison of DDT and sodium arsenite solution as poisons in grasshopper bait.

Date	Replicates	Poison per 100 Pounds of Carrier		Total Grasshoppers Caged		Average Per Cent Mortality	
		DDT, pounds	Sodium arsenite, quarts	DDT	Sodium arsenite	DDT	Sodium arsenite
Aug. 12	5	3	1	842	761	43	44
16	5	2	1	371	299	30	39
17	5	2	1	416	399	36	52
26	2	3	1½	474	453	56	59

Melanoplus devastator Scudd., *M. bivittatus* (Say), and *Camnula pellucida* (Scudd.) per square yard in alfalfa near Minden, Nev., and Gazelle, Calif.

Pyrophyllite dusts containing 50 and 10 per cent of DDT were applied with a hand duster in preliminary small-scale tests in alfalfa 14 to 20 inches tall infested with *Melanoplus devastator* and *M. bivittatus*. The 50 per cent dust caused at least 90 per cent mortality in 24 hours, and the 10 per cent dust killed about 15 per cent in dense alfalfa but failed to kill any of the grasshoppers in the open spaces. No burning of foliage was observed.

Three experiments were conducted on ¼-acre plots in green alfalfa 2 to 6 inches tall near Minden, Nev., in which DDT was compared with sodium arsenite solution (32 per cent As_2O_3) in a bait composed of 100 pounds of standard wheat bran and 16 gallons of water. One experiment was conducted on duplicated 2½-acre plots of sparse alfalfa stems and matted dry grass, comparing DDT and sodium arsenite solution in a bait composed of 100 pounds of approximately equal weights of mill-run wheat bran and old sawdust and about 10 gallons of water. The 50 per cent DDT-pyrophyllite dust was used in sufficient quantities to provide the amounts of the active ingredient given in table 1. All baits were applied at the rate of about 10 pounds of the carrier per acre. Grasshoppers were swept from the plots and adjacent unpoisoned check areas about 2 hours after the baits had been applied and held in cages 3 days for observation of mortality. The results are given in table 1.

Analysis of these results showed that in short succulent alfalfa 3 pounds of DDT per 100 pounds of bran was equal in efficiency to 1 quart of the sodium arsenite solution, but that 2 pounds of DDT was significantly less effective.

In the field containing sparse alfalfa stems and matted dry grass, the bait containing 3 pounds of DDT per 100 pounds of carrier was practically as efficient as that containing 1½ quarts of the sodium arsenite solution.

In other field experiments 3 pounds of DDT per 100 pounds of carrier was 24 per cent more effective in green alfalfa than 3 pounds of sodium fluosilicate, and 13 per cent less effective in a single trial in a dry alfalfa field.

The bait containing DDT killed the grasshoppers much more quickly than that containing sodium arsenite, especially where the grasshoppers had been feeding on succulent vegetation, the rapidity of its action resembling that of sodium fluosilicate.

DDT as a Substitute for Derris Against the European Corn Borer

D. D. QUESTEL

Preliminary laboratory and field tests conducted at Toledo, Ohio, in 1943 indicate DDT to be the most promising substitute for ground derris spray thus far tested for the control of the European corn borer in early-market sweet corn.

A proprietary mixture containing 5 per cent of DDT was used in these tests. The spray suspension was made by adding ground DDT powder as

Table 1.—Comparative effectiveness of DDT and derris sprays against the European corn borer, as shown by laboratory tests.

Material	Pounds per 100 Gallons of Water	Per Cent Active Agent in Spray	Per Cent Mortality of Borers
DDT mixture	4	0.024 DDT	100
	2	0.012 DDT	99
	1	0.006 DDT	97
	½	0.003 DDT	71
Ground derris root	1	0.0058 Rotenone	100
	½	0.0029 Rotenone	81
No treatment	—	—	1

Table 2.—Comparative toxicity of DDT and derris sprays against the European corn borer, as shown in field tests

Material	Concentration Pounds per 100 Gallons	Per Cent of Active Agent	Borers in—		Per Cent Reduction of Borers in—	
			100 plants	Ears from 100 plants	Plants	Ears
DDT mixture	6	0.036 DDT	260	68	92	96
Ground derris root	4	0.0225 Rotenone	118	36	96	98
No treatment	—	—	3226	1764	—	—

purchased to a small quantity of water containing the amount of wetting agent required and then diluting with water to the desired concentration.

Laboratory tests of DDT compared with ground derris root (4.8 per cent rotenone) gave the results shown in table 1.

Tolerance tests conducted in the field at rates of 2, 4, 6, and 8 pounds of DDT mixture per 100 gallons of water previous to the regular spraying season showed no injury to the corn plant at any concentration.

In the field toxicity tests were made comparing DDT with other materials in randomized plots replicated four times. The results obtained with DDT and derris (4.7 per cent rotenone) are given in table 2.

At present DDT is the only one of many materials tested that holds promise of becoming a satisfactory substitute for ground derris or cube, because of its relatively high reduction of borers in both ears and plants without injury to the corn.

DDT Against Some Pests of Vegetable Crops

C. A. WEIGEL

The toxicity of DDT to certain insects and mites that attack vegetable crops was studied at Beltsville Research Center in the spring and summer of 1943. Most of the tests were made in the laboratory or greenhouse. The material was applied in aerosol form or as sprays or dusts.

AEORSOLS.[1]—An aerosol mixture containing 2 per cent (by weight) of DDT in methyl chloride was given a preliminary trial against the green peach aphid, *Myzus persicae* (Sulz.), on radish; common red spiders, *Tetranychus* spp., on radish and bean; and the citrus mealybug, *Pseudococcus citri* (Risso), on coleus. The infested plants were placed in a double-walled glass fumigation chamber of 16-cubic-foot capacity in which 34 grams of the aerosol had been released, where they were exposed for 2½ hours. Examinations after 48 hours showed mortality of 86 per cent of the 226 aphids present on the radish plant, but only 6 per cent of 197 red spiders on the bean plant, 20 per cent of 88 red spiders on radish leaves, and 6 per cent of 183 mealybugs on the coleus cutting. The finding of many newly hatched red spiders on the treated plants a week later indicated that the eggs were not affected.

In another test an aerosol containing 2 per cent of DDT and 4 per cent of orthodichlorobenzene in methyl chloride was used against the same pests and in the same manner. When the plants were examined 3 days later, there was a mortality of 98 per cent of 198 green peach aphids, 67 per cent of 275 red spiders, and only 25 per cent of 119 mealybugs (mostly nymphs). The eggs of red spiders and mealybugs were unaffected, since subsequent hatching was observed. Slight injury occurred on the coleus cutting only.

SPRAYS AND DUSTS.—In an exploratory test a spray containing 4 pounds of 5 per cent DDT per 100 gallons of water was applied to a bean plant infested with the common red spider and to snapdragon cuttings infested with the green peach aphid. An electrically operated compressed-air sprayer was used. After treatment the sprayed cuttings were kept growing in a bottle of water, whereas the potted bean plant was returned to the greenhouse until mortality counts were completed. Of 119 red spiders examined after 48 hours 13 per cent appeared to be dead, whereas of 340 individuals examined 8 days later only 5 per cent were dead. Apparently many of the affected red spiders had recovered. The normal mortality in the checks was 6 per cent of 313 red spiders. A kill of 38 per cent of 422 aphids was recorded within 48 hours after treatment. No injury to the bean or snapdragon plants was apparent.

A small-scale test on the same kind of plants and pests was also made with the 3 per cent DDT dust. The material was applied with an improvised duster operated with an atomizer bulb. Four days after dusting, 51 per cent of 355 green peach aphids and 12 per cent of 129 red spiders were dead.

In greenhouse tests on the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), potato cuttings were sprayed or dusted with DDT, and each stem was then placed in a bottle of water anchored in a 4-inch pot of sand. Five adult beetles were confined within a celluloid cage that was placed over each treated cutting. Three replicate cages were used for each treatment. When the 3 per cent dust was applied, all but one of the beetles were killed in 48 hours and all were dead after 72 hours. With a spray containing 8 pounds of 5 per cent DDT per 100 gallons of water, all the beetles were dead in 4 to 7 days. At 6 pounds per 100 gallons the spray was less effective. In a number of tests that followed in the greenhouse and in outdoor cages, results similar to those above were obtained on the adults, but the larvae were killed more rapidly. No plant injury was observed.

In cage tests against the potato flea beetle, *Epitrix cucumeris* (Harr.), 10 adults were placed on potato plant cuttings that had been sprayed or dusted with DDT. The cuttings were kept growing by placing the stem ends in a bottle of water. Complete mortality was obtained in 24 hours with a 3 per cent dust and in 72 hours with a spray containing 4 pounds of 5 per cent DDT per 100 gallons of water. The dust caused slight yellowing of the potato leaves within 4 days after treatment, whereas the spray caused no injury.

When applied to growing plants in the greenhouse, neither the 3 per cent dust nor a spray containing 8 pounds of the 5 per cent DDT caused any mortality of adults and larvae of the Mexican bean beetle, *Epilachna varivestis* Muls., within 24 hours after application. The test insects were placed on the plants (confined in cages) after the insecticide was applied. None of the larvae died within 7–10 days. Coworkers who used DDT dusts and sprays against this insect on bush beans growing in their victory gardens reported poor success.

[1] The aerosol mixtures were prepared by L. D. Goodhue.

Tests with DDT Against the Pea Weevil

RALPH SCHOPP and TOM A. BRINDLEY

In laboratory tests at Moscow, Idaho, adult pea weevils, *Bruchus pisorum* (L.), collected from stored peas were dusted with 2 strengths of DDT. Five replicates were made on different dates. In each replicate about 50 weevils were distributed in 5 small cages and placed under a bell jar into which the desired quantity of dust was blown at constant pres-

sure. The weevils were allowed to remain in the bell-jar exposure chamber for 5 minutes and then transferred to larger screen cages in order to remove them from direct contact with the dust. They were held 10 days in a cabinet at a temperature of 86° F. for observation. No prospective remedy for the pea weevil was indicated by these tests, for only 62 per cent mortality was obtained with 0.3 gram of 10 per cent DDT, and only 11 per cent mortality with 0.15 gram of 2 per cent DDT. In comparable groups of undusted weevils the mortalities were 3 and 8 per cent.

Laboratory Tests with DDT Against the Pea Aphid and the Mexican Bean Beetle

F. H. HARRIES

The toxicity of DDT to the pea aphid, *Macrosiphum pisi* (Kallt.), and the Mexican bean beetle, *Epilachna varivestis* Muls., was studied at Columbus, Ohio, by dusting measured quantities of the insecticide on pea plants infested with the aphid and upon bean leaves to be fed to the beetle. The dust mixtures were applied within an especially built dusting chamber. The insects were held for 72 hours at 80° F. and 50 per cent relative humidity, after which mortality records were made.

In December 1942, all of 10 third instars of the Mexican bean beetle died within 3 days after being fed bean leaves dusted with a mixture of DDT and pyrophyllite containing 3 per cent of DDT. In a similar test a month later all of 10 third instars

Table 1.—Effectiveness of different concentrations of DDT in pyrophyllite as compared with derris against the pea aphid after 72 hours at 75° F. and 40–50 per cent relative humidity.

Insecticide	Concentration	Mortality of Adult Aphids	Surviving Progeny per Plant
	Per Cent	*Per Cent*	*Number*
DDT	10.0	100	0.2
	5.0	100	.0
	2.5	99	3.4
	1.25	99	3.0
	0.625	100	4.3
	.3125	92	9.7
	.1563	92	16.9
	.0781	88	22.6
Derris	0.5 (rotenone)	83	15.2
None		3	117.2

survived, although three-fourths of the food was eaten. During the intervening period 13 such tests were made and the average mortality was 36 per cent. In comparable tests with derris mixture (0.5 per cent rotenone) 70 per cent mortality was obtained. In later tests a mixture containing 10 per cent of DDT killed fewer larvae than did one containing 0.5 per cent of rotenone. Data on the percentage of leaf area eaten indicate that DDT had no appreciable repellent effect.

Results on wingless adults of the pea aphid indicate that, in equal concentrations, DDT in pyrophyllite is at least as toxic as rotenone in derris root mixtures with the same diluent. This is shown in table 1 by averages of 9 replicates of 10 insects in each treatment.

DDT killed both insects much faster than derris. Bean and pea plants were not injured by the material.

Field Experiments on DDT for Control of the Mexican Bean Beetle

R. H. NELSON

A DDT-pyrophyllite dust containing 10 per cent of the active ingredient was tried in two field experiments against the Mexican bean beetle, *Epilachna varivestis* Muls. Although other materials were included in these tests, only the DDT and a 0.5 per cent rotenone standard dust made with cube are reported here. The results as shown in table 1 indicate that DDT is not very effective for the control of the Mexican bean beetle.

Table 1.—Effect of DDT on field infestations of the Mexican bean beetle.

Treatment	Rate per Acre	Estimate of Defoliation	Surviving Larvae and Pupae
	Pounds	*Per Cent*	*Number*
Experiment A, results taken 14 days after a single application			
Rotenone (0.5 per cent)	23	10	49
DDT (10 per cent)	26	44	273
None	—	92	318
Experiment B, results taken 12 days after the last of 2 applications			
Rotenone (0.5 per cent)	36	3	17
DDT (10 per cent)	35	55	840
None	—	71	917

DDT for Control of the Tomato Fruitworm

G. V. JOHNSON

DDT was tested during the 1943 season for the control of the tomato fruitworm, *Heliothis armigera* (Hbn.). Comparisons were made with calcium arsenate and other materials in small field plots of tomatoes. The materials were applied as dusts, and the treatments were replicated 10 times on single-plant plots. Pyrophyllite was used as the diluent for DDT. Applications were made at the rate of 30 pounds per acre on August 10 and 24 and September 8. Comparisons of treatments were based on the number of tomatoes that were visibly injured by fruitworm larvae.

Plants dusted with 3 per cent DDT, 1 per cent DDT, and undiluted calcium arsenate produced, respectively, 51 (4.0 per cent), 101 (8.0 per cent), and 81 (6.5 per cent) worm-injured tomatoes, as compared with 401 (28.5 per cent) on untreated check plants. Analysis of variance of the results showed that 3 per cent DDT dust was significantly more effective than 1 per cent DDT or undiluted calcium

arsenate. One per cent DDT and undiluted calcium arsenate did not differ significantly in effectiveness. The results show good promise for DDT in the control of the tomato fruitworm on tomatoes, especially since the strongest dust tested contained only 3 per cent of DDT.

In laboratory tests complete mortality was obtained of 30 larvae of the tomato fruitworm when fed leaves dusted with the 3 per cent DDT. Twenty-nine of 30 others died when fed leaves dusted with the 5 per cent strength prepared commercially for use in spray mixtures. In comparable tests with calcium arsenate 25 larvae died. The deposit per square centimeter was 69, 42, and 15 micrograms of the respective materials. More feeding took place in the calcium arsenate tests than in the DDT tests.

Field Experiments with DDT Against the Potato Leafhopper and the Turnip Aphid

N. F. HOWARD

In small-plot field experiments with the potato leafhopper, *Empoasca fabae* (Harr.), a mixture containing 1 per cent of DDT, 19 per cent of Bancroft clay, and 80 per cent of sulfur was as effective as a pyrethrum-sulfur mixture containing 0.025 per cent of total pyrethrins. The tests were replicated four times in each of two experiments on potatoes and one on beans. Some of the data obtained on potatoes are given in table 1. The results on beans were similar to those obtained on potatoes. Among the other materials tested in these experiments were sulfur (undiluted) and bordeaux mixture spray, neither of which was as effective as the DDT mixture.

Table 1.—Living leafhopper nymphs found on potato plants at Columbus, Ohio, after applications of a DDT-sulfur mixture (1 per cent of DDT) and a pyrethrum-sulfur mixture (0.025 per cent of pyrethrins).

Date Insecticides were Applied	Date Leafhoppers Were Counted	Previous Applications on Same Plants	Leafhopper Nymphs Surviving per 100 Leaves After Applying—	
			DDT	Pyrethrum
		Number	*Number*	*Number*
July 21	July 22	0	104	55
Aug. 3	Aug. 9	1	45	87
July 6	July 7	0	146	177
July 6	July 12	0	89	250
July 15	July 16	1	40	166
July 23	July 24	2	24	76

Small plots of turnips heavily infested with the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis), were dusted twice with a mixture containing 1 per cent of DDT in pyrophyllite while other plots were dusted with standard insecticides. These plots were arranged in randomized blocks with four replicates of each treatment. The DDT mixture was applied with a bellows-type hand duster at the rate of 119 pounds per acre per application, the derris dust (1 per cent rotenone and 2 per cent oil) at 98 pounds, and the nicotine sulfate dust (3 per cent nicotine) at 65 pounds. The heavy applications were made because of the thick foliage and large plants with leaves a foot or more in length. The numbers of aphids surviving on four 1-inch sections of each of five random leaves of each plot 48 hours after the second application were 43, 18, and 8, following treatments with DDT, rotenone, and nicotine, respectively. There were 412 aphids on comparable undusted leaves.

Field Tests with DDT and Other Insecticides Against Cabbage Caterpillars

C. E. SMITH and P. K. HARRISON

In a study of substitutes for rotenone and pyrethrum for the control of cabbage caterpillars on cole crops, two series of small-plot field tests were conducted on fall-grown cabbage at Baton Rouge, La., in 1943, comparing the effectiveness of DDT and 10 other insecticidal preparations against these insects.

In the first series the test area consisted of 44 plots of cabbage of the Marion Market variety arranged in 4 randomized blocks of 11 plots each, 1 plot 50 feet long and 4 rows wide for each treatment. The plants were just beginning to form a head or had not quite reached that stage. The plant stand was thin, the distance between plants averaging about 30 inches, thus requiring a low rate of application of the insecticides.

The treatments consisted of two applications of the insecticides, on October 29 (3:20–5:15 p.m.) and on November 5 (3:40–5:20 p.m.). The atmosphere was almost calm during the first application, and a light breeze prevailed during the second. The air temperature ranged from 35° to 81° F., the daily mean ranging from 46.0° to 70.5° and averaging 60.5°. The rainfall consisted of 1.35 inches on October 31 and November 1, and 3.22 inches on November 6 and 7.

Two days before the first application an examination of 100 cabbage plants, taken at random over the test area, revealed the presence of 100 caterpillars, principally of the cabbage looper, *Autographa brassicae* (Riley); most of them were less than quarter grown and many were newly hatched. The other species present, also small individuals, were the imported cabbage worm, *Pieris rapae* (L.), the diamondback moth, *Plutella maculipennis* (Curt.), and various species of Agrotinae including climbing cutworms and the tomato fruitworm, *Heliothis armigera* (Hbn.).

Five days after the second application 25 cabbage plants were examined in each plot and the surviving caterpillars recorded. Table 1 shows the results.

As the data in table 1 show, DDT was superior to all the other preparations against these pests. The five looper larvae recorded on the DDT treatment had just hatched, whereas those on the other treatments were of different ages in the first instar. The single diamondback moth larva on the DDT treatment was fully grown and apparently had finished feeding for some time. The large populations surviving on the least effective treatments as compared with those present on the plants prior to the applications show that the tests were conducted during the peak of the infestation. This is corroborated by the fact that there were practically no looper or imported cabbage worm eggs present at the time the post-application examination of the plants was made.

Table 1.—Cabbage caterpillars surviving 5 days after the second application of insecticide.

Materials Used	Per Acre	Caterpillars Surviving per 100 Plants				
		Cabbage looper	Imported cabbage worm	Diamond-back moth	Agro-tinae	Total of all species
	Pounds					
DDT, pyrophyllite (1:10)	14	5	0	1	0	6
Pyrethrum, pyrophyllite (0.3% total pyrethrins)	14	51	0	10	0	61
Derris, pyrophyllite (0.5% rotenone)	18	70	0	4	0	74
Scorodite (hydrous ferric arsenate) (micronized, undiluted)	12	89	8	6	1	104
Derris malaccensis, pyrophyllite (trace of rotenone, 2.9% total ether extractives)	17	104	0	6	1	111
	Gallons					
Soap (white naphtha) 1 lb., water 5 gal.	32	111	10	4	3	128
Tartar emetic 2 oz., brown sugar 8 oz., water 3 gal.	23	145	0	3	4	152
	Pounds					
Yam bean flour, talc (1:5)	17	176	2	9	0	187
	Gallons					
White oil emulsion 1 pt., water 6 gal.	36	181	5	15	1	202
	Pounds					
Nicotine bentonite (processed) 21 lbs., powdered sugar 5 lbs., pyrophyllite 74 lbs. (3% nicotine)	16	237	6	7	2	252
Nicotine bentonite (processed) 21 lbs., pyrophyllite 79 lbs. (3% nicotine)	17	265	8	7	2	282
Differences required for significance:						
At odds of 19 to 1		76	—	7	—	78
At odds of 99 to 1		102	—	9	—	105

In further tests with DDT against cabbage caterpillars, an application of the dust was made November 12 on cabbage of the same planting not previously treated. Approximately 600 feet of cabbage row were dusted, and about 300 feet of cabbage in adjacent rows were used as a check. The dust was applied by making two trips per row, and the dosage was approximately 18 pounds per acre. A rather stiff breeze was blowing at the time of the application. The air temperature ranged from 36° to 75° F. with a daily mean range from 52.0° to 63.0° and an average of 56.0° No rain fell during the period.

Observations were made 2 hours, 20 hours, and 3 days after the application of the insecticide.

Two hours after the treatment a number of insects appeared to be affected, Several cabbage loopers and one tomato fruitworm were regurgitating and quivering, and one banded cucumber beetle was on its back, although able to move its legs and antennae. After 20 hours several of these insects were either dead or severely affected.

The principal species and number of insects of each species found 3 days after the application are given in table 2. In addition the following insects were observed on the treated plants: 1 dead honeybee, *Apis mellifera* L.; 1 dead ladybird beetle; 1 live syrphid fly larva, which was active and apparently unaffected; 1 dead three-cornered alfalfa hopper, *Stictocephala festina* (Say); 1 live southern green stinkbug, *Nezara viridula* (L.); 2 spotted cucumber beetles, *Diabrotica duodecim punctata* (F.), 1 of which was nearly dead, and 3 vegetable weevils, *Listroderes obliquus* Klug, 1 dead, 1 living, and 1 affected.

Table 2.—Insects living and dead 3 days after an application of DDT to cabbage.

Insect	Insects on 100 Undusted Plants		Insects on 200 Dusted Plants	
	Alive	Dead	Alive	Dead
Cabbage looper, larvae and pupae	111	0	8	15
Imported cabbage worm, larvae and pupae	4	0	2	0
Diamondback moth, larvae and pupae	13	0	4	0
Banded cucumber beetle, adults	8	0	2	20

Tests of DDT for Cabbage Insects and Squash Bugs

P. K. Harrison

The effectiveness of DDT dust as compared with 2-chlorofluorene, derris, and yam bean flour against several insects that commonly attack cabbage and

Table 1.—Mortality of insects dusted with DDT and other materials in laboratory tests. 1943.

Insect and Insecticide	Date Dusted	Number in Test	Time Days	Mortality Per Cent
Harlequin bug, adults:				
DDT (10 per cent)	July 29	25	2	100
	Aug. 18	20	2	100
2-Chlorofluorene (20 per cent)	Aug. 18	20	2	100
Derris (0.75 per cent rotenone)	Aug. 18	20	2	100
Yam bean flour (20 per cent)	Aug. 18	20	2	50
Southern green stinkbug, adults and nymphs				
DDT (10 per cent):	July 29	5	2	100
	Aug. 23	25	4	76
2-Chlorofluorene (20 per cent)	Aug. 23	25	4	80
Derris (0.75 per cent rotenone)	Aug. 23	25	4	24
Yam bean flour (20 per cent)	Aug. 23	25	4	80
DDT (10 per cent)	Sept. 6	30	4	100
	Sept. 8	25	5	100
2-Chlorofluorene (20 per cent)	Sept. 8	25	5	64
Imported cabbage worm larvae, one-third to nearly grown:				
DDT (10 per cent)	Aug. 3	10	3	90
2-Chlorofluorene (20 per cent)	Aug. 3	10	3	90
Derris (0.75 per cent rotenone)	Aug. 3	10	3	100
Yam bean flour (20 per cent)	Aug. 3	10	3	0
Cross-stripped cabbage worm larvae, one-third to nearly grown:				
DDT (10 per cent)	Aug. 3	5	3	100
2-Chlorofluorene (20 per cent)	Aug. 3	5	3	80
Derris (0.75 per cent rotenone)	Aug. 3	5	3	80
Yam bean flour (20 per cent)	Aug. 3	5	3	0
Squash bug, adults and nymphs:				
DDT (10 per cent)	Aug. 19	18	2	100
	Sept. 20	50	7	94
	Sept. 21	240	6	100
2-Chlorofluorene (20 per cent)	Sept. 20	50	7	92
Derris (0.75 per cent rotenone)	Sept. 20	50	7	96
Yam bean flour (20 per cent)	Sept. 20	50	7	26

against squash bugs was studied at Baton Rouge, La., during the summer of 1943. The tests were conducted in cages in an insectary that was enclosed on three sides with window screening and glass. The insects were the harlequin bug, *Murgantia histrionica* (Hahn); the southern green stinkbug, *Nezara viridula* (L.); the imported cabbage worm *Pieris rapae* (L.); the cross-striped cabbage worm, *Evergestis rimosalis* (Guen.); and squash bugs, *Anasa* spp.

Portions of host plants, which included cabbage, squash, cowpeas, and okra, were placed in bottles containing water and the tops around the plants plugged with cotton. The bottles were then partially imbedded in benches containing sand and covered with screen cages. The insects were introduced several hours, sometimes overnight, previous to the application of the insecticides. The insecticides were applied with small plunger-type dusters through the side of the cage or the open door. The dosages were not measured.

The results, which are summarized in table 1, show high mortality of the insects dusted with DDT. The tests were not sufficiently replicated, however, to warrant drawing definite conclusions: they merely indicate that further studies should be made with this material.

DDT to Control Thrips on Gladiolus

FLOYD F. SMITH

Several DDT sprays were compared with a standard tartar emetic spray during 1943 at Beltsville, Md., as a control for the onion thrips, *Thrips tabaci* Lind., on Ebenezer onions and the gladiolus thrips, *Taeniothrips simplex* (Morison), on gladiolus. Plots of onions consisted of 25 sets and those of gladiolus 50 bulbs each. Six replicates in randomized blocks were conducted on each insect. The same quantity of DDT was applied in all sprays. Six weekly applications were made between June 14 and July 19, during a period of extreme drought. The results of the treatments on onions were based on weights of bulbs harvested from each plot in August, and computed on the basis of yield per acre, as given in table 1. (As a basis for comparison, the average per-acre yield in New York State is 23,642 pounds.) The effectiveness of the treatments against the gladiolus thrips was based on injury to the lower florets on flower spikes that developed during July and August.

According to an analysis of variance of the yields of onions, the tartar emetic-brown sugar spray was superior in all treatments and the untreated check.

Table 1.—Control of the onion thrips and the gladiolus thrips by DDT sprays in comparison with tartar emetic.

Material in 100 Gallons of Spray	Onions		Gladiolus					
			La Paloma			Flaming Sword		
	Yield per acre	Increase over checks	Total flowers	Uninjured flowers	Control	Total flowers	Uninjured flowers	Control
	Pounds	*Per Cent*	*Number*	*Number*	*Per Cent*	*Number*	*Number*	*Per Cent*
Untreated checks	14,025	—	105	42	—	89	35	—
Tartar emetic 2 lb., brown sugar 4 lb.	24,129	72	100	92	87	72	59	70
DDT (5 per cent) 7.5 lb.	21,807	55	105	92	79	88	64	55
DDT (5 per cent) 7.5 lb., brown sugar 4 lb.	18,228	30	91	86	91	77	56	55
DDT (1 per cent) in deodorized kerosene 4 gal., soap 8 lb.	22,418	60	91	90	100—	46	38	71
Deodorized kerosene 4 gal., soap 8 lb.	15,382	9	83	24	0	29	2	0
Difference required for significance at odds of 19 to 1.	1,443	10.3	—	38.5	—	—	13.4	—

While all DDT sprays were better than the untreated checks or the oil emulsion without DDT, the one containing brown sugar was inferior to the DDT alone or to the DDT-oil emulsion.

On the gladiolus variety La Paloma the control with DDT approximated that obtained with tartar emetic. Of interest was the protection obtained by DDT in the absence of the sugar. On the variety Flaming Sword DDT was slightly, but not significantly, inferior to the tartar emetic spray, while the two sprays containing oil emulsion were decidedly inferior because of their deleterious effect on the plants, including flower production.

No ill effects were observed on the onion foliage, although a slight white deposit was left by the treatments with DDT alone and with brown sugar. The injury by thrips feeding decreased from severe silvering on the lower yielding untreated and oil-emulsion-treated plots to slight injury on the higher yielding tartar emetic-treated plots. On the gladiolus foliage, DDT, with or without brown sugar, left a slight white deposit and apparently caused scattered rusty-brown spots. The oil emulsion containing DDT caused severe yellowing and death of many plants of the variety Flaming Sword and less severe injury to La Paloma. The oil emulsion alone seemed to cause more injury than did that containing DDT.

DDT as a Protective Spray Against the Japanese Beetle

WALTER E. FLEMING and ROBERT D. CHISHOLM

During the summer of 1943 DDT was found to be the most effective of the protective materials tested against the Japanese beetle, *Popillia japonica* Newm.

A finely pulverized mixture of this material with an equal quantity of calcite was made into a thin paste with fish glue and put into the nearly full spray tank, after which a commercial (83 per cent) summer-oil emulsion was added at the rate of 0.5 pint per pound of DDT.

In laboratory tests using smartweed, *Polygonum pennsylvanicum*, as a test plant, sprays containing 0.25 pound of DDT per 100 gallons were consistently as effective as those containing 6 pounds of lead arsenate in protecting the plants from attack.

In field tests one application of a spray containing 0.25 pound of DDT to 100 gallons of water protected the fruit and foliage of early varieties of peach trees for about 10 days, which was the same protection as that given by two applications of the recommended spray containing ground derris root and rosin residue emulsion. The single application of 1 pound of DDT to 100 gallons of water afforded satisfactory protection to the fruit and foliage during the period when the beetles were attacking the trees.

The presence of large numbers of dead beetles under the trees sprayed with DDT indicated that this material acted as a poison, in addition to any repellent value it may have.

One application at the rate of 1 pound per 100 gallons on heavily infested plum trees destroyed the infestation and kept the trees free from beetles for the remainder of the season, even though peaches and nectarines in the immediate vicinity were severely attacked. When this spray was applied to several rows of grapes in a vineyard where an infestation of beetles was established, only an occasional beetle was observed on the sprayed vines during the remainder of the season, while the adjacent unsprayed vines were heavily infested.

There was no evidence of injury to fruit and foliage of peaches, plums, or grapes. DDT appears to be a very promising substitute for the derris, lime-aluminum sulfate, and lead arsenate sprays recommended for control of this insect. It remains effective for a longer period than derris and has the advantage over the lime and the lead arsenate sprays in that it leaves no conspicuous residue on the fruit and foliage.

Laboratory and Field Tests of DDT for Control of the Codling Moth

L. F. STEINER, C. H. ARNOLD, and S. A. SUMMERLAND

Three lots of DDT were utilized in tests against the codling moth, *Carpocapsa pomonella* (L.), at Vincennes, Ind., in 1943. In two lots the DDT was in a coarse and gummy form. In most of the tests this material was prepared by first sifting or grinding in a mortar, and then grinding with water in a pebble mill shortly before use.[1] The third lot was a finely ground mixture of DDT and pyrophyllite (50:50), which was put into a suspension with a small amount of water before the final dilution was made.

LABORATORY TESTS.—In preliminary experiments 19 lots of 40 to 60 apples each were sprayed with DDT, alone or mixed with pyrophyllite or with certain fungicides, adhesives, and spreaders. In some tests duplicates of sprayed samples were exposed to tap-water sprays to obtain information concerning their probable relative susceptibility to weathering. Each apple was exposed to the attack of 10 newly hatched larvae.

LABORATORY-FIELD TESTS.—In these tests eight 1- or 2-tree plots were thoroughly sprayed with regular equipment. Stratified samples of 60 apples were taken from each plot before and after each spray and exposed, under laboratory conditions, to the attack of 10 newly hatched larvae per apple. The methods used have been described elsewhere (Steiner 1939).

In these tests DDT at only 1 pound per 100 gallons was highly effective, even after long periods of weathering. For example, between August 14 and September 14, which included nine rainy periods with a total precipitation of 2.46 inches, the effectiveness of a deposit from four applications between June 25 and August 14 declined from 100 per cent only to 89 per cent. On a Grimes Golden plot, where five DDT sprays at 1 to 2 pounds per 100 gallons were applied between June 5 and August 12, the effectiveness after 1 to 3 days was 99.8 per cent; at the close of the interspray period and at harvest it was 92 per cent. The maximum effectiveness reached during the season by the standard lead arsenate treatment was only 69.8 per cent.

Other tests suggested that DDT could probably be used effectively after first-brood sprays of either nicotine bentonite with soybean oil or lead arsenate and lime with mineral oil. The results with DDT following nicotine bentonite near the end of the first two interspray periods were significantly better than those where DDT followed lead arsenate. The differences at harvest, however, were not found to be significant.

When supplemented with 0.5 per cent of mineral oil and 1 pound of bentonite, DDT gave no better results than when used alone. A 1–2–100 bordeaux mixture had no adverse effect until between 2 and 4 weeks after the final spray, when the percentage of clean apples dropped from 99 to 78 following rains that totaled 2.31 inches. The decline on the plot where no supplements were used was only half as great.

In tests in which 2500 eggs were deposited by caged moths on one of the Grimes Golden plots before and after an application of 1.5 pounds of DDT per 100 gallons, no ovicidal effect could be detected. Neither the deposits nor the sprays of DDT appeared to be toxic to the moths, although this matter required further investigation.

Table 1.—Results of small-plot field tests with DDT, lead arsenate, and nicotine bentonite against late codling moth larvae in an orchard previously treated with a lead arsenate schedule.

Plot	Treatment (quantities per 100 gallons)	Per Cent of Clean Apples	Number per 100 Apples		Per Cent Increase in Worm Entrances After July 21
			Worms	Stings	
1	Tank-mix nicotine bentonite[1]	23	107	81	664
2	Lead arsenate, 3 lbs.[2] Aug. 28 spray omitted	26	109	96	623
3	Same as 2, but including Aug. 28 spray	31	85	104	435
4	DDT, 0.75 lb.[3]	54	31	51	103
5	DDT, 1.5 lbs.[3]	59	12	56	−21
	Least significant difference (odds 99:1)	21	62	41	—

[1] Nicotine sulfate (40 per cent) 0.67 pt., Mississippi bentonite 5 lbs., and soybean phosphatide spreader 2 oz.
[2] With copper sulfate 0.5 lb. and lime 1 lb.
[3] Mixed with an equal quantity of pyrophyllite.

At 1 pound per 100 gallons the DDT appeared significantly more effective than lead arsenate at 3 pounds, giving nearly perfect control. Adhesives such as mineral oil, bentonite, or weak bordeaux mixture did not increase the resistance of the material to weathering. Spreaders or supplements containing wetting agents usually did not reduce the initial kill, but did reduce the effectiveness after the deposits had been exposed to additional sprays of tap water. For example, the larvicidal effectiveness of 2 pounds of the DDT-pyrophyllite mixture per 100 gallons changed from 99.6 per cent only to 98.7 after five tap-water sprays, but when 4 pounds of wettable sulfur was added the effectiveness declined from 98 to 60 per cent. Very poor results, as to both initial efficiency and resistance to the water sprays, were obtained when the DDT was dissolved in acetone and reprecipitated in a mixture containing flocculated bentonite and a soybean phosphatide spreader.

[1] Prepared for use by J. E. Fahey, who also made analyses to determine the coverage in the field tests.

FIELD TESTS.—Near the peak of the second-brood hatch small-plot field tests were started in a well-sprayed commercial orchard, where the grower's lead arsenate program had failed to give satisfactory control in previous years and was again failing. In spite of the application by mid-July of six complete cover and two top-off sprays with 3.2 to 4 pounds of lead arsenate per 100 gallons, supplemented with nicotine sulfate and with mineral oil in several of the covers, 4000 apples on 20 mature Winesap trees examined on July 21 averaged 15 worm entrances and 34 stings per 100.

Five plots were arranged in a restricted randomization with four single-tree replicates in each. All drops were removed on July 21, and the experimental sprays were applied on July 22 and August 12 and 28. The treatments and results are given in table 1. Drops that fell after July 21 are included.

The average crop was from 2870 to 3180 apples in the different plots. At harvest on October 2 from 40 to 44 per cent of the crop had dropped in the lead arsenate and nicotine plots, but only 24 to 32 per cent in the DDT plots. Not only did the DDT at 1.5 pounds prevent worm entrances, but there were no new stings at harvest and less than 3 per cent of the picked apples were wormy. The presence of many hatched eggs on fruit in this plot is evidence that the complete control of worm entrances did not result from the avoidance by ovipositing moths of trees sprayed with DDT. Many new injuries were observed on the lead arsenate and nicotine plots, and 25 per cent of the picked fruit on plot 3 contained worm entrances, in spite of adequate coverage as shown by analyses.

EFFECT OF DDT ON ORCHARD MITES.—In July the European red mite, *Paratetranychus pilosus* (C. and F.), became noticeably more abundant on trees sprayed with DDT than on unsprayed trees or on those to which other treatments had been applied. As many as 40 mites and 100 unhatched eggs were found on a single leaf in the DDT plots. On August 24 it was noted that the lady beetle *Stethrus punctum* (Lec.) was absent from the DDT plots in the small field-plot tests though present in large numbers on the adjacent lead arsenate and nicotine plots. Subsequently this predator moved into the DDT plots in both the laboratory-field and small-plot-field experiments and checked the threat of a severe mite outbreak.

At harvest, however, large populations of the common red spider (*Tetranychus* spp.) were found on the fruit and under bark on all trees sprayed with DDT in the field-plot tests, while this pest was difficult to find on all the other trees.

SPRAY INJURY.—No injury occurred on any of the 11 Winesap trees that had been sprayed with DDT, but all the Grimes Golden trees developed injury which may have been caused by the DDT. Irregular dead patches developed between the veins of nearly 25 per cent of the leaves, which turned yellow or dropped. All the foliage on these trees gradually became a lighter green than that on unsprayed trees. There was no association between the location of visible deposits of DDT and the injured areas. The injury appeared on most of the trees by August 24, but on 2 trees that had been sprayed with nicotine bentonite prior to July 6 the injury did not develop until later. By October 1 the leaf loss on all 9 trees approximated 75 per cent, compared with a 10 per cent loss on unsprayed trees. The injury may have been caused, or aggravated, by the increased mite population and extremely hot dry weather which prevailed between July 6 and September 2.

It is important to note that the injury was as serious on trees that received two applications of DDT at 1 pound per 100 gallons, the second on July 27, as on one tree that was given five applications, the last on August 12. Until the phytocidal effect of this material on all varieties can be investigated under different climatic conditions, it should be used with caution.

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Laboratory Tests of DDT Against the Codling Moth

E. H. SIEGLER

A proprietary insecticide that was reported to contain 5 per cent of DDT was first tested in this laboratory in March 1943, against newly hatched codling moth larvae, *Carpocapsa pomonella* (L.). The resulting data were sufficiently favorable to warrant further investigation.

DDT was then tested at various concentrations, both alone and in combination with other spray materials, by the apple-plug method. Approximately 100 plugs, each of which was infested with a ready-to-hatch codling moth egg, were used in each test. When DDT was used alone, it was first dissolved in ethanol by gentle heating and then precipitated by adding water to make a 20 per cent

Table 1.—Toxicity of DDT, alone and combined with other materials, to codling moth larvae.

Concentration, Pounds per 100 Gallons	Added Material, per 100 Gallons	Days from Time Sprayed to Time Infested	Percentage of Apple Plugs	
			Wormy	Stung
4	None	0	1	1
		5	0	3
		6	5	5
3	None	0	1	3
	Hydrated lime, 6 lbs.	6	4	18
	Diglycol stearate, 2 oz.	4	1	0
	Pyrophyllite, 6 lbs.	4	3	0
2	None	0	6	12
		6	11	2
		9	18	10
	Neutral fish oil soap, 0.25 lb.	0	7	21
	Bentonite, 8 lbs.	0	23	7
	Lime-sulfur, 1 gal.	0	20	27
	Hydrated lime and wettable sulfur, 6 lbs. each	0	14	9
	Bordeaux mixture, 4 to 8 lbs.	0	2	7
1	None	0	16	12
0.5	None	0	22	17
		7	62	12
0.25	None	0	44	3
		7	68	4

ethanol carrier. When combined with other materials, the compound was merely ground in a mortar and mixed with them, using water as the carrier.

The results are given in table 1. It will be noted that DDT exhibited excellent promise when used alone at concentrations of 1 or more pounds per 100 gallons. It showed little to no loss in effectiveness when combined with bordeaux mixture, diglycol stearate, neutral soap, or pyrophyllite, but the addition of hydrated lime, bentonite, lime-sulfur, or hydrated lime plus wettable sulfur reduced its toxicity somewhat. In the same series of tests lead arsenate, 4 pounds to 100 gallons, gave 44 per cent of wormy and 5 per cent of stung plugs. The unsprayed plugs were 93 per cent wormy, and none of them were stung.

During the season of 1943 small-scale field spray tests were made on young Rome apple and Elberta peach trees growing outdoors. By means of a hand sprayer a single application of each spray (pounds per 100 gallons) was made, with the following results: DDT, 4 pounds, plus pyrophyllite, 4 pounds—no injury to apple and moderate injury to peach; DDT, 3 pounds, plus bordeaux, 4-8-100—moderate injury to apple; DDT, 3 pounds, plus wettable sulfur, 6 pounds, plus hydrated lime, 6 pounds—no injury to apple or peach. In a test of lead arsenate, 4 pounds, plus hydrated lime, 4 pounds, there was no injury to apple and moderate injury to peach. A test of DDT, 4 pounds, on Concord grape caused severe foliage injury.

Tests of DDT as a Contact Insecticide Against Females of the Fall Cankerworm

J. V. SCHAFFNER, JR.

A severe infestation of the fall cankerworm was discovered in a stand of mixed hardwoods a short distance from the laboratory at New Haven, Conn., in November 1943, a few days after the moths began to emerge. Since a small quantity of DDT was on hand at the time, tests were made to determine the effectiveness of this material as a contact insecticide against the female moths. The females are wingless and upon emerging from their pupal cases in the ground they crawl up onto the trees, where they mate and deposit their eggs.

The following field tests were made: (1) Seven trees were banded with burlap that had been saturated with an emulsion containing 5 per cent of DDT; (2) the trunks of four trees from the base up to about 4 feet above the ground were sprayed with a similar emulsion; (3) the trunks of five trees from the base up to about 4 feet were dusted with a 50–50 mixture of DDT and pyrophyllite (Pyrax).

These tests were supplemented by others in the laboratory. The DDT used in the tests had not been micronized, and different dosages could not be tried because of the limited supply of the insecticide.

The DDT-pyrophyllite dust was effective in killing moths that came in contact with it for a very short period of time. The moths did not die immediately but they quickly lost all power of locomotion.

The DDT emulsion was not very effective in the field, but moths confined in a cloth-covered cage (9 by 9 by 15 inches) the inside of which had been sprayed with this emulsion soon lost all power of locomotion, and died within 24 to 48 hours.

DDT and the Mexican Fruitfly

C. C. PLUMMER

Several concentrations of DDT were prepared by dissolving it in 20 milliliters of acetone. Each acetone solution was then made up to 200 milliliters by the addition of a solution containing 20 pounds of granulated sugar and 1 pound of dried Chinese egg albumen in 100 gallons of water. When DDT was used at the rate of 8 pounds per 100 gallons (1.9172 gram in 20 milliliters of acetone), small needle-like crystals of DDT were thrown into suspension, but when 0.5, 1, 2, and 4 pounds were used per 100 gallons, the suspensions appeared to be fine and amorphous. The usual 5 milliliters of preparations were pipetted onto 4-by-6-inch pebble-surfaced glass plates and observed under a binocular microscope upon drying. No crystalline material was detected on the surface of the plates. At 2, 4, and 8 pounds per 100 gallons small round masses of DDT were observed on the plates, but preparations at 0.5 and 1 pound were almost clear and the material was evenly distributed on the plates.

Methods described by Plummer (1943) were followed in testing the toxicity of this material to adults of the Mexican fruitfly, *Anastrepha ludens* (Loew), at 25° C. Tests were started at 6 A.M. Five cages, each with 25 flies of each sex, were used to test each concentration of DDT. Similar numbers of flies were exposed to a similarly prepared tartar emetic solution at 2 pounds per 100 gallons.

Toxicity data for the three highest DDT concentrations and for tartar emetic are shown in figure 1. The toxicity of DDT was very erratic, more so than any other compound we have tested against adults of *Anastrepha ludens*. All the flies died upon exposure to 2 and 4 pounds, but after tests had been continued for 794 hours 2 (females) of the 247 flies survived in cages where 0.5 pound was given, 4 (females) flies survived of the 248 flies exposed to 1 pound, and 17 flies (4 males, 13 females) survived of the 250 flies exposed to 8 pounds. The lines for concentrations of 0.5 and 1 pound fell between those for 2 and 4 pounds. Two pounds of tartar emetic was considerably more toxic than any of the concentrations of DDT tested.

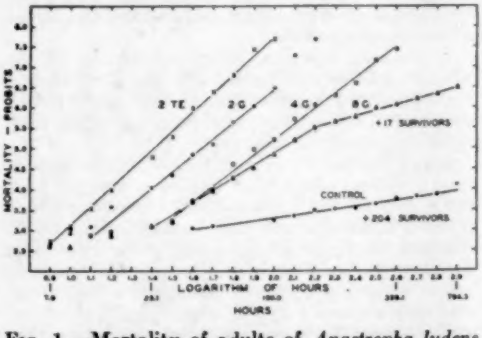

FIG. 1.—Mortality of adults of *Anastrepha ludens* exposed to 2 pounds of tartar emetic (2 TE) and to 2, 4, and 8 pounds of DDT (G) per 100 gallons.

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DDT as a Stomach and Contact Poison for Honeybees

E. C. HOLST

A report by Wiesmann (1942) states that a 1 per cent solution of Gesarol Spraying Agent (0.05 per cent of DDT) is not toxic to bees as a stomach poison, but does kill bees when sprayed directly on them. Since an insecticide of this type, effective against insect pests yet not harmful to honeybees, would be of much interest to both horticulturists and beekeepers, it appeared advisable to conduct further tests.

Wiesmann's work was of a preliminary nature, since only one trial with 10 bees was reported. His method of feeding a 1 per cent Gesarol Spraying Agent in a honey-sugar syrup to caged bees was repeated, and the testing expanded to include feeding the insecticide in dilute honey and in queen-cage candy. At least 20 young bees per cage were used in each test. In 6 such trials the majority of the bees were dead within 17–42 hours, whereas few or no bees in the 6 control cages died.

Both drones and worker bees were affected. Several hours after taking candy or syrup containing DDT the bees become agitated; later they become shaky and unsteady, being unable to maintain a firm footing. Shortly before death the bees at intervals would fall over and arise again. Near the end, unable to stand, their legs kept up a characteristic quivering. No internal or external changes in appearance to differentiate bees dying from this cause could be found on dissection or on gross examination.

No contact-poisoning effect of 0.05 per cent DDT was demonstrated when bees were kept in cages previously sprayed or when the bees were sprayed directly. However, when bees were placed in cages previously sprayed with 1 and 2 per cent of DDT, within 6 hours most of the bees died, and the rest were definitely poisoned.

These data show that DDT definitely is a stomach poison for honeybees at 0.05 per cent concentration, and at 1 per cent also acts as a contact poison.

LITERATURE CITED

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OBITUARY

Elmer Darwin Ball 1870-1943

On October 5, 1943 Elmer Darwin Ball, for some 50 years one of the most prominent and active men in the Entomological Profession and a past president of the American Association of Economic Entomologists, died.

He was born at Athens, Vermont, September 21, 1870. While a mere youngster his parents moved to Iowa where he was reared as a farm boy. This experience was of great value to him later in life in many official agricultural capacities. His keen observation brought to his attention the problems of entomology early in life so that when entering Iowa State College he was soon majoring in Entomology and received the B.Sc. degree from that Institution in 1895, working under the tutelage of Professor Herbert Osborn. The following two years he spent as Assistant Entomologist in the Iowa Agricultural Experiment Station and received his Masters degree in 1897. The following year he became Assistant Entomologist in the Colorado Agricultural Experiment Station. In 1902 he was appointed to the position of Entomologist in the Utah Agricultural College. In 1906 he obtained a leave of absence to enter the Ohio State University to work again with Professor Osborn and received the Doctor of Philosophy degree in 1907. The same year he was promoted to the position of Dean of Agriculture and Director of the Experiment Station of the Utah Agricultural College. From 1916 to 1918 he served as State Entomologist of Wisconsin and was appointed Professor of Zoology and Entomology at Iowa State College in 1918. In June 1920 he obtained a leave of absence to become Assistant Secretary of Agriculture in Washington, D. C., which position he held until October 1921 when he was appointed to the position of Director of Scientific Work of the United States Department of Agriculture which he held until 1925. From 1925–28 he was in charge of celery insect investigation at Sanford for the Florida State Plant Board. In 1928 he became Dean of Agriculture and Director of the Experiment Station at the University of Arizona and in 1931 was appointed to a Research Professorship in Zoology and Entomology at that Institution, which position he held until retirement in 1939.

Dr. Ball was a man of enthusiasm, determination, courage and devotion to duty. He was tireless in his field and laboratory efforts and his zeal and enthusiasm carried him far beyond the point to which his physical strength should have been taxed. He could lead a group of younger enthusiasts on mountain collecting hikes all day and still not seem to be physically exhausted.

Throughout his many years of busy official capacities he found time to carry on extensive collecting and taxonomic work with several groups of Homoptera. In this field he was outstanding for his keen powers of observation and his tireless energy fitted him for an excellent taxonomist. His published works and his large collection of Homoptera containing hundreds of types, now deposited in the U. S. National Museum, will always stand as a memorial to his outstanding contribution to science in this field. Through his interest in this group he contributed especially to two important economic problems by demonstrating in 1906 that the beet leafhopper was the vector of curly top in sugar beets and in 1918 that the potato leafhopper caused hopperburn in potatoes.

In his official executive positions, Dr. Ball attempted to raise the standards of entomology and science in general. He was willing to risk friends and friendships to establish milestones in higher training, and higher salaries for trained scientific workers. It was through such efforts that he was able to bring about the Graduate School in the U. S. Department of Agriculture, a Bureau of Home Economics and a Bureau of Agricultural economics. Similar efforts were made in the positions he held as Dean and Director of various state agricultural colleges.

We thus find him holding important positions as an executive, administrator, dean, director, teacher, field and laboratory research worker, economic entomologist, ecologist and taxonomist.

While his co-workers did not always agree with his decisions, his sincerity and enthusiasms were greatly admired and in his passing we have lost a friend and a great champion of entomology.

D. M. DELONG

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The Golden Age of Entomology

IN CERTAIN respects this might be called the "Golden Age of Entomology." Never in the history of this science has it risen to such heights of importance and recognition. In the armed forces the entomologist is standing shoulder to shoulder with the medical doctors, the sanitary engineers, and also with the combat officers and soldiers. The problems of insect borne diseases; malaria, typhus, yellow fever, filariasis or elephantiasis, dengue fever, and others, are now recognized by all to be vital in the winning of the war and have made entomologists indispensable to the armed forces. Since the University of California alone has approximately 50 members of its staff and graduates in this service all other institutions must have a sufficient number to bring the total well up to over a thousand entomologists in the medical and sanitary units; and there are many others at home doing work in these same fields. Never before in the history of the world has medical entomology seen such well earned recognition!

In economic or agricultural entomology there is at present a dearth of men to solve the many added problems in connection with crop production; protection of stored, milled, and processed food products; protecting domestic animals from arthropod borne diseases and arthropod infestations; preserving timber and wood products; and keeping the farmers advised as to the most efficient methods of using the rapidly diminishing supplies of essential insecticides.

The insecticide manufacturers have had great need for more entomologists experienced in the knowledge of toxicology in order to supply all possible substitutes for insecticides that have been limited because of more urgent needs in industry. We can serve industry and economic entomology by providing well trained and cooperatively minded entomological toxicologists to fill these positions.

A factor that may seem trivial, but which in the end, may be an extremely important one in the future development of entomology is the victory garden program. The twenty million victory gardens and sixty million gardeners with their multitudinous insect problems are sure to make a large part of our population insect conscious. For the first time most of these people will have actually seen live, plant-consuming and crop-destroying bugs, lice, beetles, weevils, caterpillars, maggots, and mites. They will have their first experience in losing something which they have toiled to produce; they will have learned how to apply dusts, sprays, and baits in an attempt to protect their property only to find that much of their time and labor has been for naught. But out of it all will come knowledge and experience that will make for a better understanding and greater appreciation of the entomologists who are able to take care of all these many problems necessary to safeguard and insure food production, health, and comfort. Many of these amateur gardeners are men and women who may at the present time or in the future be influential in making laws and providing appropriations for insect eradication or control programs and it is almost certain that they will view such problems with more interest and support than has generally been the case in the past. Therefore we should see to it that the entomologists have a worthy share in the victory garden program in every section of the country.

Entomologists should be alert to the opportunities of the future. Our profession must take on the dignity worthy of its membership: a dignity that admits neither impossibilities nor defeats with respect to any and all entomological problems.

Among the many problems that confront us perhaps, the most important have to do with

1. *Teaching* and preparing young men and women in the most thorough manner. In too many instances students—even those with the Ph.D. degree—are at the present time taught little more than the meager fundamentals of insect classification and biology and the simple methods of applying insecticides and calculating their effects upon the host plants and the insect pests attacking them. Specialization in teaching has done away with a great deal of the old-time thoroughness in giving the student the well-rounded biological and entomological background that resulted in the training of so many of our older entomologists. As the profession matures and ages, the vast amounts of knowledge must in some way be sifted and made available as a background upon which to build present-day and future experience and knowledge. Yet how many departments of entomology attempt to familiarize their students with the historical background and accomplishments of entomology from a national and world viewpoint? More attention to systematics, morphology, physiology, ecology, toxicology, and related subjects are imperative. Agriculture, which we serve, must have a generous share in our preparation. Educational institutions still offer no substitute for having been reared on a farm for those who elect to take up experiment station work in agricultural entomology. Better entomological libraries and adequate reference collections are essential to good teaching. A prospective teacher should be investigated as to his own personal library and collection as well as to his interest, training, experience, and accomplishments.

2. *Research.* An Institution where no research is in progress is hardly a worthy place to seek an entomological education. It is true that certain men, who do little or no investigational work, are often splendid teachers, but such teachers should be bolstered by others who are obsessed with their desire for original research.

At no other time has there been such a demand for investigational work. Taxonomy is always a needy field and in medical entomology more work is being done on mosquitoes during a space of a few years than during a decade in the past and on other insects affecting human health and domestic animals, stored product insects, and new insecticides than at any time in previous history. Manufacturing insecticide companies are increasing their entomological research staffs as rapidly as trained men are available and some companies are setting up new well-endowed research laboratories that will no doubt draw some of the best talent from state and federal projects.

It might be well to take all possible means to guard against false economics which are very likely to restrict and handicap research during the reconstruction period after the war.

3. *Publications.* Something drastic needs to be done about the publication of important articles relating to all fields in entomology. This is not a new idea, but is none the less vital to the future of our profession. The time has long been passed when single generalized types of journals will serve a large association, society, or similar organization unless the subscription price is sufficiently increased very greatly to enlarge the publication. Many of us belong to three, four, or more organizations, each of which publishes a journal to which we subscribe and it is a fact, in many cases at least, that one cannot at any time publish a paper of any consequence in a single one of these organs short of a wait of from one to three or fours years! The publication of a substantial monograph is wholly out of the question and has been for several years except in a very few specially endowed institutions. To the research worker, who wishes to publish and to receive printed information, and to the teacher and investigator who wishes to procure the results of up-to-date experiments the present condition is most difficult. Of the many suggestions that have already been made to correct this situation these may be worthy of consideration:

1. Enlarge the present journals and increase the subscription price. This idea is perhaps most worthy of consideration, especially in cases where the publication is not already too bulky to make this practical.
2. In other cases it does not appear feasible and the apparent solution might be to issue two or more series under the same title or to print separate publications. Such specific publications could carry more pertinent information to the specialized

investigator and reader and would best serve their interests. However, the issuance of several series or journals by any organization would not mean that every member would subscribe for all the publications and some difficulties are likely to arise from such an arrangement.

3. Print separately larger papers, monographs, symposia, and reviews. This practice is being followed by certain organizations with some success.

Journals and other official organs of societies, associations and similar organizations such as those in entomology are not to be regarded as money-making ventures. They are among the most important contributions of such organizations and in most cases are one of the chief reasons for the organizing and continued existence of all scientific groups. To become more efficient and more useful to their members they should strengthen this very useful means of disseminating reliable entomological information not only to membership but to the whole world for the needs of today and to perpetuate for the future.

There are many other immediate and post-war problems to be considered. It is expected that the present Committee on Coordination of Entomology with the War Effort will continue their work for there may still be many problems arising before the war is over. The appointment of still another committee on post-war planning is contemplated and these two committees might cooperate very closely and be important factors in the life of our association during this crisis.—1-12-44.

PRESIDENT ESSIG ANNOUNCES NEW COMMITTEES

Among the duties of the incoming president is the appointment of certain new committees that have to deal with important problems that arise and which cannot always be handled by existing committees. Because there is no other way to create these committees, it has been left to the president and the Executive Committee to make the appointments. In connection with all of these committees, the president has sought the advice of the Executive Committee and other officers and also certain past presidents in order that the personnel of each committee might be fully examined and approved.

The Committee on the Coordination of Entomology with the War Effort:

This committee was created two years ago and has served very diligently during this period. In view of the continuance of the war, it seemed very desirable that the committee should also be continued, as nearly as possible in its original form. This has been done with but one change and that is the appointment of Professor J. S. Houser to take the place of Dr. Phillips as chairman. This of course was done only at the very urgent request of Dr. Phillips. The work of this committee has been important and may be more important in the future than in the past. Many new problems are likely to arise which may be definitely handled by this group. If any member of the Association has in mind matters that should be placed before this committee, I am sure that Chairman Houser and all other members of the committee will be very pleased to receive them. The membership of this committee is as follows:

E. N. Cory — L. M. Peairs
S. A. Graham — E. F. Phillips
A. S. Hoyt — P. D. Sanders
J. S. Houser, *Chairman*

The creation of projects and project leaders as well as sub-committees to carry on the work of this committee are wholly within the province of this body. With Secretary Cory and Editor Peairs as members of the committee, we may look forward to seeing reports of progress of the committee from time to time in the JOURNAL or perhaps through other sources. I am sure that all of the members of the Association are concerned with work of the committee and if they cannot actually contribute to the accomplishments of the committee, they will be interested in hearing of its program and progress.

The Committee on Codifying the Regulations and Statements of Policy:

A resolution adopted at the Columbus meeting provided for the appointment of a committee to be "charged with the duty of codifying the regulations and statements of policy which have from time to time been enacted. That the report of this committee be submitted to the Executive Committee for approval and shall then be published in the JOURNAL OF ECONOMIC ENTOMOLOGY.

"That the committee be further instructed to draft such amendments for modification as may seem to be necessary to clarify obscure or conflicting points and to cover needed regulations not now existing, and to present such problems at the next regular meeting of the Association. That this committee be instructed to formulate for each Association Committee a charter of duties as indicated by the constitution enacted for the organization."

In agreement with the Executive Committee, the following committee has been appointed:

A. F. Burgess — E. N. Cory
H. B. Weiss, *Chairman*

This committee has been organized and is already hard at work on what is sure to be a very splendid accomplishment for the organization.

A committee on Post-War Entomology is being organized and the membership will be announced later.

E. O. ESSIG

BOOK REVIEW

On Your Own. By Samuel A. Graham and Earl C. O'Roke. University of Minnesota Press, Minneapolis, Minn. 1943. 150 pages, illustrated, 52 text figures. $2.00.

Few persons, five years ago, would have ventured the prediction that in the immediate future American boys in great numbers, from the farms and city streets, would be called on to live and care for themselves in tropic jungles, desert wastes, and arctic tundras. Yet these things have come to pass, and the little volume under review is an attempt to smooth the way of those persons who may find themselves in unfamiliar, and possibly dangerous, surroundings. It is appropriately subtitled "How to Take Care of Yourself in Wild Country. A Manual for Field and Service Men."

The section titles suggest the contents, "How to Meet Physical Extremes," "Preventing and Treating Minor Injuries and Infections," "Your Food in the Field," "How to Avoid Animal Diseases," and "Equipment You Will Need in the Field," to mention a few of them. There are discussions of edible plants, the catching of wild animals, poisonous plants, insects and other animals that attack man, or are vectors of diseases to which he is subject, and other related matters.

The illustrations, many of them from original drawings, supplement the text to its great advantage. There is a highly usable table relating to disease carriers which names the disease, its causative agent, the method of transmission, the carrier, and the general distribution of the causative organism. Under "General Advice" the authors have included much practical informations and many helpful suggestions.

Since their wild-country experience has largely been in the United States, especially in the northern forests and the western semi-arid lands, the authors have drawn rather heavily on these regions for illustrative and factual material. They have realized, wisely it seems to the reviewer, that no manual of usable size and scope could include details of all the food or poisonous plants, or all the annoying arthropods of the world. For information relating to the tropics they have gone to accepted sources, but they have adopted the viewpoint that certain fundamental problems of protection from exposure and disease, and of food getting, are inherent in any wild situation; no manual may hope to be a ready-made guide to all the facets of any one such situation. Local information must supplement general directions, and this may best be gained on the spot.

Much of the information which the volume contains is known to the average field scientist, and the book is not designed primarily for him. Yet when one experiences the carelessness to exposure, and the lack of exact information on such a subject as the treatment of snakebite betrayed by many persons in the field who ought to know better, he realizes that Doctors Graham and O'Roke have prepared a manual which has usefulness far beyond the requirements of the armed services and the war emergency.

M. G. Brooks

Eighteenth Annual Western Co-operative Spray Conference

The eighteenth annual conference of the Western Cooperative Spray Project was held at Portland, Oregon on January 19 and 20. Those present at this official conference included entomologists, chemists, horticulturists and plant pathologists engaged in state or federal research work on orchard spraying problems in the West.

There were informal discussions on dormant sprays, and on sprays for the codling moth, pear psylla, red spider, cherry fruit fly, pear thrips, filbert insects and various fungous diseases. Of particular interest was a discussion of the characteristics of spray oils which came up in connection with the economic poisons law recently put into effect in the State of Washington. The suggestions for the use of orchard sprays, issued annually by this group, were brought up to date.

The conference adjourned at noon of the second day for a group luncheon with representatives of insecticide manufacturers and distributors, field men of growers' organizations and horticultural inspectors. Afterwards a joint meeting was held, presided over by E. T. Doy of the Tobacco By-Products and Chemical Corporation, at which Dr. Alvin J. Cox of the California Department of Agriculture showed a motion picture film on the manufacture and use of insecticides and fungicides in California. There was an attendance of 92 at this joint meeting.

The following members of the Spray Project were in attendance:

California

A. D. Borden
Alvin J. Cox

Idaho

W. E. Shull

Washington

D. F. Allmendinger
D. J. Crowley
Kermit Groves
Larry Harman
Folke Johnson
L. K. Jones
M. C. Midgley
W. J. O'Neill
E. L. Overholser
F. L. Overley
L. G. Smith
J. L. St. John
Kenneth C. Walker
R. L. Webster

Oregon

Leroy Childs
L. G. Gentner
S. C. Jones
Don C. Mote
Robert E. Rieder
R. H. Robinson
Joe Schuh
B. G. Thompson
S. M. Zeller

Utah

C. J. Sorenson

U. S. Department of Agriculture

C. C. Alexander
F. P. Dean
S. M. Dohanian
K. A. Haines
J. R. Kienholz
T. L. Kirkpatrick
E. J. Newcomer

E. J. Newcomer, Yakima, Wash., was chairman of the conference, and F. L. Overley, Wenatchee, Washington, was the secretary.

F. L. Overly, *Secretary*

PEST CONTROL OPERATORS CONFERENCE

The eighth annual pest control operators conference was held at Purdue University from January 17 to 20, 1944. The first day of the conference was devoted to fundamentals, instruction being furnished by the members of the Entomology staff of Purdue University, J. J. Davis, Howard O'Deay and B. E. Montgomery. A skit on termite control, both amusing and instructive occupied the evening of the same day and was followed on Tuesday by a session in which termite biology and control were considered in a more serious fashion.

Tuesday afternoon was given over to fumigation problems including fumigation materials and practices as well as general discussions of questions raised by present wartime conditions. Tuesday evening offered various features including a talk on the delusions and halucinations of the public in matters pertaining to insects, by George Elliott, President of the National Pest Control Association, a discussion of relapsing fever by Dr. H. C. Whitmire, presentation of moving pictures of ticks by Dr. Whitmire and others on rats and rat control by G. C. Onderdonk.

On Wednesday Dr. Dove, of the Bureau of Entomology and Plant Quarantine, discussed post-war problems in the pest control industry and elsewhere and gave demonstrations of the use of aerosol bombs. Following this was a demonstration of the Shafer Prone Method of Resuscitation by Dr. H. G. DeKay. Mr. Ira Batfields' fine discussion of powder post beetles was also a part of the program. Rat control was the order of the day for Wednesday afternoon and the annual Dinner occupied the evening.

On Thursday Mr. Wm. O. Buettner discussed material and man-power priorities; Lt. Colonel P. C. Mortenson talked about army pest control problems and Carl E. Weiman discussed research in pest control.

Attendance at the conference totalled 160, representing 19 states and Canada. The pest control operators in attendance made a substantial contribution to the Purdue PCO Student Loan Fund.

It should be a matter of regret to many entomologists that they are unable to attend, as learners rather than instructors, these valuable and well-conducted conferences, but cause for gratification lies in the fact that they are being continued in spite of wartime difficulties. Certainly they are more essential now than they are under normal conditions.

HORTICULTURAL INSPECTION NOTES

Federal quarantine No. 72 was amended effective January 14, 1944, to include new places where white-fringed beetles have been found. Brought within the regulated area for the first time are parts of the counties of Baldwin and Crenshaw in Alabama, Hancock and Simpson in Mississippi, and parts of the North Carolina counties of Anson, Cumberland, and Onslow.

Due to the recent discovery of the pink bollworm in southwestern Louisiana, a public hearing was held March 1, 1944, at Memphis, Tenn., to consider the advisability of extending the Federal quarantine to include area in Louisiana.

The State of Virginia, effective December 31, 1943, revoked its two quarantines pertaining to the European corn borer, regulating interstate and intrastate movement of the host products. The pest has been reported from 39 counties in Virginia and appears to be spreading westward from the tidewater counties, according to the Department of Agriculture and Immigration.

Recent revisions of the corn borer quarantines of Arizona, Iowa, Missouri, and Nebraska extended the regulated areas to include 57 counties in Iowa and 26 in Missouri. The city of St. Louis is also brought within the regulated area in the quarantines of the three Midwestern States.

The Connecticut Agricultural Experiment Station has published the 1944 edition of "Laws and Regulations Concerning the Inspection of Nurseries in Connecticut and Transportation of Nursery Stock." This publication, Circular 158, summarizes the Federal and Canadian plant quarantines and regulations as well as the general nursery-stock shipping requirements and quarantines of the various States.

The fumigation of sweetpotatoes for weevils is authorized, with certain limitations, as a condition of entry into Alabama and Mississippi from the regulated areas, in recently revised quarantines of these States. This provision will be found in Amendment No. 1, effective February 7, 1944, to Alabama Quarantine Order No. 2, and in Mississippi Rule 24A, amended September 13, 1943. Greene County, Miss., has been added to the regulated area.

A revision of the Colorado quarantine pertaining to oriental fruit moth, effective January 1, 1944, permits the entry of fumigated host fruits only during the summer months (unless fumigated in the period specified and subsequently stored in approved storage); prohibits entry of unfumigated used containers from the infested areas and also from unidentified areas; and extends the regulated area to include those counties and States that were found infested in 1943.

California Quarantine Regulation No. 8 pertaining to the citrus whitefly in that State, was revoked effective December 15, 1943, the eradication program having reached a stage, according to State pest-control officers, where it is no longer necessary to restrict the movement of host plants from any areas in California that were formerly infested.

Vetch weevil infestations are shown in 7 counties in Washington State, an addition of 3 since 1939, according to a revision of the intrastate quarantine No. 22-a, effective December 29, 1943.

Third Annual Meeting of Pacific Northwest Vegetable Crop Insect Control Conference

The third annual meeting of the Northwest Truck Crop Insect Control Conference was held in Pullman, Washington, and Moscow, Idaho, on January 17 and 18, respectively. Entomologists from the Northwest States of Idaho, Montana, Oregon, Utah and Washington were in attendance. As in previous sessions, new developments in the control of pests affecting vegetable crops in the Northwest were discussed informally. H. B. Mills, H. E. Morrison, W. E. Shull, and Keith Sime acted as discussion leaders during the four sessions. The first two sessions were held on the campus of Washington State College and the third and fourth meetings were conducted on the campus of the University of Idaho. The annual banquet was held in Pullman.

Three exceptionally fine talks were presented at the Annual Banquet. There were: "Highlights of the Annual Meeting of the American Association of Economic Entomologists and the American Entomological Society" by L. G. Smith, "Insects Affecting Vegetable Crops in Matanuska" by J. C. Chamberlin, and "New Developments in Vegetable Insect Control" by W. H. White.

The following members attended the conference:

W. W. Baker	Puyallup, Washington
David L. Bischoff	Vancouver, Washington
E. P. Breakey	Puyallup, Washington
Tom A. Brindley	Moscow, Idaho
J. A. Callenbach	Moscow, Idaho
Joseph C. Chamberlin	Forest Grove, Oregon
W. C. Cook	Walla Walla, Washington
Bill Courtney	Sumner, Washington
D. J. Crowley	Long Beach, Washington
E. W. Davis	Union Gap, Washington
F. E. DeSellem	Olympia, Washington
C. F. Doucette	Sumner, Washington
J. R. Douglass	Twin Falls, Idaho
R. D. Eichmann	Pullman, Washington
C. W. Getzendanner	Union Gap, Washington
F. A. Kirsch	Yakima, Washington
L. Kirkpatrick	Spokane, Washington
G. F. Knowlton	Logan, Utah
H. P. Lanchester	Walla Walla, Washington
B. J. Landis	Union Gap, Washington
M. C. Lane	Walla Walla, Washington
R. E. Miller	Dayton, Washington
H. B. Mills	Bozeman, Montana
Paul J. Moody	Spokane, Washington
H. E. Morrison	Corvallis, Oregon
C. S. Nichols	Chehalis, Washington
G. D. Radebaugh, Jr.	Dayton, Washington
Robert E. Rieder	Corvallis, Oregon
Joe Schuh	Corvallis, Oregon
W. E. Shull	Moscow, Idaho
L. G. Smith	Pullman, Washington
C. J. Sorenson	Logan, Utah
R. L. Webster	Pullman, Washington
W. H. White	Washington, D. C.
G. W. Young	Chehalis, Washington

The Executive Committee in charge of the arrangements for the 1944 meeting were W. E. Shull, University of Idaho, Moscow, Idaho, Chairman; M. C. Lane, United States Department of Agriculture, Co-chairman; and Tom A. Brindley, U. S. Department of Agriculture, Secretary, The staffs of the Entomology Departments of the University of Idaho and Washington State College acted as hosts for the meeting.

The following Executive Committee was elected for the coming year: H. B. Mills, Montana State College, Chairman; J. R. Douglass, U. S. Department of Agriculture, Co-chairman; and Tom A. Brindley, U. S. Department of Agriculture, Secretary.

Tom A. Brindley, *Secretary*

Description of the Profession of Entomology Issued by The War Manpower Commission

Occupational Summary.

The scientific study of insects is divided into two general groupings; physiological and systematic entomology, and economic entomology.

a. The former approach is concerned with the classification, morphology, evolution, physiology and genetics of insects.

b. The latter is concerned with insects in their relation to crops, commodities and man; specifically the life history of insects and their ecology; their eradication or control through use of insecticides, fumigants, heat, cold, or light, and natural enemies, parasites and predators, as other insects or birds.

c. It is also concerned with the planning and enforcement of regulatory measures to prevent the spread of insect pests, with the education of farmers and others in the prevention or control of infestations, and in identification of pests.

d. Another specialty is the study of plant and animal disease transmission by insects. One phase of this field, medical entomology, deals with the control of insect-borne diseases, such as malaria, through entomological research and field studies of anopheline mosquitoes, the carriers of malaria.

e. Other specialties are: apiculture, or the study of bees; sericulture or silkworm culture; toxicological entomology, studies of the toxic effects of different insecticides on both insects and the infested plants.

f. The entomologist is familiar with the technical design of experiments, the statistical analysis of experimental data, and the preparation of scientific reports. He prepares bulletins, setting forth in non-technical language, the results of experiments in a specific branch of entomology.

Major Branches

Economic entomologists usually specialize by insect pests of particular crops, commodities, or animals, while the entomologists in other areas specialize by subject matter approaches indicated in Group II.

I. Economic Entomology—Insect pests of:
   a. Raw and manufactured commodities, as cereals, dried fruits, animal products, fabrics, forest products.

b. Field and cultivated crops, as truck, cereal and forage crops, cotton and tobacco.
c. Fruits, nuts and shade trees, including grapes and berries.
d. Forest trees, including log pests.
e. Man and animal, principally mosquitoes, flies, lice, roaches, bots, etc.
f. Foreign commerce—pests found in imported commodities and in carriers (ships, airplanes, etc.)

II. Other Specialties in Entomology
a. Systematic or taxonomic—classification and identification of insects.
b. Morphological—insect anatomy.
c. Physiological—functioning of the insect organism; reactions to environmental conditions, as light, temperature, food, moisture, etc.
d. Genetic—mechanism of inheritance of characteristics.
e. Medical—manner and control of diseases transmitted by insects to man.
f. Toxicological—development and effectiveness of insecticides.
g. Apicultural—bee-culture and breeding.
h. Sericultural—silkworm culture and breeding.

Functional Specializations

Entomologists specialize in any one or more of the well-defined function areas listed below in addition to their specializations under major branches;

1. Research—principally through experiments and field surveys.
2. Editing and writing.
3. Inspection—to control spread of pests or introduction of new pests in foreign commerce.
4. Extension work—education of farmers, distributors, manufacturers and the public in the practical application of scientific methods and practices with respect to their insect pest problems.
5. Teaching at the college and university level.
6. Management and administration of field operations, state and Federal bureaus, laboratories, etc.

Professional Affiliations and Civil Service Ratings.

In determining the professional status of an individual, some weight can be given to membership in a national or local professional group. Full membership in such groups is generally limited to individuals who have acceptable professional qualifications. Lack of such membership, however, should not be construed as indicative of nonprofessional status.

In those states which operate under a merit system and in the Federal Civil Service, a professional job classification or a professional rating on a civil service register is ordinarily indicative of the professional status of the entomologist.

Educational Qualifications

a. The minimum of a bachelor's degree in the field of entomology; occasionally in zoology or some specialized branch thereof.
b. In a very few cases in which the formal professional training is more limited, there must be evidence of many years of progressive and varied professional experience which can be considered as the equivalent of the formal training which is lacking.

Related Professional Fields

Entomology is closely allied to, and is often considered as a major branch of zoology. It is likewise related to parasitology, since either profession may concern itself with the various insect parasites of man and animals; to plant pathology and to bacteriology insofar as the transmission of bacterial and viral diseases by insects is concerned; to pharmacology from the standpoint of the toxicology of insecticides; to agricultural chemistry from the stand point of the development and testing of insecticides; to animal husbandry and veterinary science in the area of pests of domesticated animals.

Related Non-professional Occupations

Individuals qualified only in any of the following occupational areas cannot be classified as entomologists on the basis of such experience.

beekeeper
scientific aide (helper or assistant)
laboratory technician (assistant)
inspector insect pest, grain, cattle tick
exterminators, commercial
fumigators, commercial

Industry

Entomologists are employed principally in the following industries:

government, state and Federal
universities and colleges
non-profit research institutions

PROGRAM

JOINT MEETINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA AND THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, COLUMBUS, OHIO, DECEMBER 7, 8 AND 9, 1943

The War and the Future of Entomology

Annual Presidential Address, P. N. ANNAND, *President*
American Association of Economic Entomologists

SYMPOSIUM

Medical Entomology in Wartime

(Dr. C. E. Mickel, presiding; F. C. Bishopp, Discussion Leader)

Relation of Insects to the Health of Military Personnel. Major O. R. McCoy, Office of Surgeon General.
Entomologists and the Sanitary Corps. Colonel W. A. Hardenburg, Office of Sanitary Engineers
Insect Control at Army Training Camps in the United States. Major Stanley J. Carpenter, Army Sanitary Corps.
Problems of Medical Entomology of Military Importance in Canada. Major R. H. Ozburn, Royal Canadian Army Medical Corps.
Mosquito Problems in the American Tropics. W. H. Komp, United States Public Health Service
Chemical Control of Insects Which Affect Man's Health and Comfort:
Fumigation. Randall Latta.
Repellents, Contact Insecticides and Larvicides. E. F. Knipling and T. C. Allen
Aerosols. L. D. Goodhue

SYMPOSIUM

Agricultural Entomology in Wartime

(Dr. P. N. Annand, Presiding; J. J. Davis, Discussion Leader)

The Insecticide Situation. L. S. Hitchner, Agricultural Insecticide and Fungicide Association
The Distribution of Allocated Insecticides. C. C. Hamilton, War Food Administration
Insect Surveys and the Distribution of Insecticides. S. A. Rohwer.
The Effect of Shortages of Rotenone and Pyrethrum on Crop Protection and Production. C. E. Palm.
Substitute Agricultural Crop Insecticides. Neal F. Howard and Roy Hansberry
Farm Stock Insecticides. W. E. Dove and J. Munro
Protection of Dried Packaged Foodstuffs for Military Uses From Insect Damage. E. O. Essig and B. N. Smallman.
Protection of Stored and Dried Processed Foods and Seed Supplies From Insect Damage. R. T. Cotton.
Insect Problems of Seed Production. L. G. Smith and John M. Hughes.
Bees and Seed Production. J. I. Hambleton.
The Pest Control Industry and the War. Wm. O. Buettner.
Entomological Problems of the Victory Gardener. T. H. Parks.
The Influence of the War on Plant Quarantines. E. R. Sasscer.
Extension Entomology Activities and the Food and Fiber Production Programs. M. P. Jones.
The Manpower Problem in Entomology. E. N. Cory.
The Relation of Entomology to Conservation. Philip F. Allen.

(Papers from the above program will be published in the April and June members of the JOURNAL OF ECONOMIC ENTOMOLOGY.

PROCEEDINGS OF THE FIFTY-FIFTH ANNUAL MEETING

American Association of Economic Entomologists

Deshler-Wallick Hotel, Columbus, Ohio, December, 1943

The meetings of the American Association of Economic Entomologists, held jointly with the Entomological Society of America in Columbus December 7, 8 and 9, were an outstanding success and, in the opinion of all present, fully justified even under wartime conditions by the very obvious timeliness of the programs and the essential information which was there presented and thus made immediately available for use in all parts of the country now, when it is most urgently needed.

The theme of the program—"Entomology and the War"—was universally acclaimed; the papers and discussions engaged the closest attention of the 264 registrants and many visitors from the outstanding address of President Annand with which the program opened to the final adjournment. The Program Committee had formulated a coherent program, grouped the papers to the best advantgage and by judicious selection of volunteer papers supplemented by volunteer contributions, provided a very competent survey of the role of entomology and entomologists in the war effort. The program may well serve as a model for those to come in future years as providing a compact and adequate consideration of progress made and problems of the immediate and more distant future.

The speakers selected by the committee were authoritative and well prepared and were well worthy of individual mention which space here will not permit. So attractive was the program and the arrangement of the meeting room with tables and facilities for taking notes, that the lobby conferences were notable for their scarcity. The well-handled discussions of the groups of papers added much to the total value of the sessions.

The meetings were presided over by Dr. C. E. Mickel, of the Society and Dr. P. N. Annand, of the Association, who were ably assisted by the discussion leaders, F. C. Bishopp and J. J. Davis, an innovation which stimulated discussion and effectively kept it on the subject at hand.

The thanks of the Association and the Society are due the Program Committee, W. H. White and C. F. W. Muesebeck, and also the local committee on arrangements, T. H. Parks assisted by D. M. DeLong and Neale F. Howard.

Two Sectional meetings were held, one by the Section on Apiculture and the other by the Section on Extension. There was also a well-attended conference on the European Corn Borer and many smaller informal conferences on other topics as well as the many necessary committee meetings.

Possibly the most gratifying feature of the meetings was the evidence, so unmistakable in many forms, of the recognition that entomology has won from the armed forces. Representatives of both the Army and the Navy were present, entomologists and others, and there was at all times, visual evidence that the program was indeed concerned with "Entomology and the War."

A list of the titles of the papers read at the meetings is presented herewith. The papers from this program submitted for publication in the *Journal* will be grouped appropriately and published in the issues for April and June, so far as that may be possible.

The open meeting of the Executive Committee was held on the evening of December 7. Discussion and approval of the several committee reports and consideration of new business occupied the evening.

The general Business Session of the Association was held on December 8. Final presentation of the reports of standing committees was the first order of business. These reports were considered and adopted and are printed as approved in the pages to follow.

The Membership committee presented the names of 96 applicants, all of which had been approved and recommended by the committee. On motion the applicants were elected to membership. Names of the new members will be found in the report of the Membership Committee. The committee also made formal note of the deaths of several members during the past year and of the resignation of others. A summary of the present membership status of the Association is presented in the report of the Secretary of the Association.

The Nominating Committee, represented by Dr. F. A. Fenton, presented its report.

Dr. E. O. Essig, of Berkeley California was nominated President and Mr. S. A. Sohwer, of Washington, D. C., First Vice-President for the year 1944. On motion these men were unanimously elected. A list of nominees to the various standing committees to fill vacancies was presented and the chairmen of these committees were nominated by the Committee. The list was approved by the vote of the Association. Names of the new committee members appear in the report of the Committee.

Reports of the several other committees which had been presented to the Executive Committee were read by the Secretary and approved by the Association in the form in which they occur in this report. These committee reports covered the new business. After some discussions and announcements the meeting was adjourned.

The following pages present the report of the Secretary-Treasurer and the committee reports which summarize the business of the Association.

The section in Apiculture held a meeting at noon on December 7, 1943, in room 222 Deshler-Wallich hotel. Following the luncheon W. A. Price was elected Chairman *pro-tem* to serve in the absence of Chairman W. O. Park.

There was a single number on the program, an invitational paper entitled "Beekeeping in Two Wars" by Dr. E. F. Phillips. This interesting presentation furnished the substance and background for the lively discussions that followed.

In the business session at the conclusion of the program two officers were elected for the coming year. They were, J. A. Munro, *Chairman*, and W. A. Price, *Secretary*.

W. A. Price, *Secretary*

Executive Committee Meeting, December 7, 1943

The Executive Committee met in the evening of December 7 and, after thorough discussions, formulated the following recommendations which were considered and adopted at the Annual Business Meeting of the Association on December 8.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE FISCAL YEAR ENDED NOVEMBER 30, 1943

	TOTAL	JOURNAL	ASSOCIATION	INDICES I–V	INDEX VI	INDEX VII
Receipts:						
Subscriptions	$ 6,369.32	$ 6,369.32				
Advertising	196.86	196.86				
Reprints	1,351.55	1,351.55				
Back numbers and miscellaneous	390.48	390.48				
Printing expenses paid by Eastern Branch	428.57	428.57				
Dues	2,507.25		$1,882.93		$ 75.13	$549.19
Common Names and miscellaneous	23.29		23.29			
Sales of indices	493.45			$185.35	308.10	
Bond interest	50.00		50.00			
Total Receipts	11,810.77	8,736.78	1,956.22	185.35	383.23	549.19
Disbursements:						
Auditing and accounting fees	67.00	33.50	33.50			
Surety bond for secretary	12.50	6.25	6.25			
Safe deposit box rental	3.60		3.60			
Printing	13,995.76	9,087.95			4,907.81	
Engravings, drafting, etc.	470.44	470.44				
Honorarium, secretary and business manager	600.00	300.00	300.00			
Stenographic and clerical	283.25	141.62	141.63			
Travel	252.97		252.97			
Committee expenses	44.41		44.41			
Branch expenses: Cotton States	34.43		34.43			
Pacific Slope	65.81		65.81			
Postage, stationery and supplies	589.41	294.70	294.71			
Telephone and telegraph	53.85		53.85			
Express	193.90	8.63			185.27	
Refunds	19.93	13.93			6.00	
Bank service charges	32.74	16.37	16.37			
Total Disbursements	16,720.00	10,373.39	1,247.53	—	5,099.08	—
Excess of Receipts Over Disbursements	4,909.23*	1,636.61*	708.69	185.35	4,715.85*	549.19
Add Balance November 30, 1942	8,417.16	3,166.13	3,069.42	148.26	1,802.35	231.00
Balance November 30, 1943	$ 3,507.93	$ 1,529.52	$3,778.11	$333.61	$2,913.50*	$780.19

This balance is represented by the following:

Prince Georges Bank & Trust Company (checking account)	$ 1,507.93
U. S. Defense Bonds, Series G (2½% interest)	2,000.00
	$ 3,507.93

Note: The gross deficit for the year ($4,909.23) is mainly attributable to the publication of Index VI ($5,099.08). The Association publishes an index only about once every five years.

* Indicates Deficit.

STATEMENT OF PERMANENT FUND

Balance, November 30, 1942, as per previous report		$24,825.09
Income for the period:		
Interest received from securities	$317.50	
Interest received from savings deposit	55.81	
Interest credited to book value of U. S. Bonds	300.00	
Total Income		673.31
Balance, November 30, 1943		$25,498.40

The balance is invested as follows:

	PAR VALUE	BOOK VALUE	
Securities:			
Province of Ontario, 5's	$ 2,000.00	$2,000.00	
U. S. Treasury Bonds, 3¼'s	2,500.00	2,484.00	
U. S. Treasury Bonds, 2½'s	3,000.00	2,984.00	
U. S. Savings Bonds, Series A	5,000.00	4,500.00	
U. S. Savings Bonds, Series D	10,000.00	8,300.00	
U. S. Defense Bonds, Series G, 2½'s	2,000.00	2,000.00	
Total Securities			$22,268.00
Bank Deposit (Savings Account):			
Prince Georges Bank & Trust Co. (2%)		3,096.66	
Unclipped coupons (Deposited Dec. 4, 1943)		133.74	3,230. 0
Total Investments in the Permanent Fund			$25,498.40

1. That the name of the Plant Quarantine and Inspection Section be changed to Plant Pest Control and Quarantine.
2. Attention be called to the fact that the Program Committee has been authorized to adjust programs, by action of the Association at San Francisco.
3. The Program Committee be instructed to develop morning programs of papers of general interest that may be either invitation or submitted papers and that the other volunteer or submitted papers be placed in existing sectional or special sectional meetings organized by the Committee.

4. Art. III. Sec. 2. be amended to read: The Publications Committee shall consist of seven members to be elected for terms not to exceed three years in duration. Any member may be reelected for one additional term. (The election in 43 and 44, to follow the suggestions have been circulated by the Editor.)
5. The complete report of the Publications Committee be adopted.
6. The special committee on *Entoma* be discharged and the thanks of the Association extended to the members for their constructive work.
7. The Committee on the Promotion of Official Entomology be discontinued.
8. In view of the liquidation of the Tropical Research Council, our representation be discontinued and the thanks of the Association be extended to Dr. Osborn for his services as Representative.
9. The Committee on the Inter-American Entomological Congress be discontinued.
10. A Committee on the Affiliation of Entomologists in the Americas to consist of E. R. Sasscer, *Chairman*, C. O. Eddy, A. C. Baker, T. R. Hansbury, Edson Hambleton, Geo. N. Wolcott, H. G. Crawford and E. N. Cory, to study and develop the best methods of promoting close cooperation between all entomologists in the Western Hemisphere. This Committee to report, at the next annual meeting, their findings as to the best procedure to achieve the desired ends and to make recommendations with regard to the future composition and terms of election of the Committee.
11. The Committee on membership study and report at the next annual meeting, the entire matter of the qualifications of members, the election of members, the function of the Committee, and make recommendations as may seem to be indicated with regard to all classes of membership.
12. The Committee on Conservation be enlarged to five members and that they give consideration to the best division of the task assigned.

REPORT OF THE SECRETARY-TREASURER

Membership in the Association stands as follows:

Active members (March 15, 1943)		1576
Resignations	16	
Deceased	14	
Dropped	41	
	71	
Applications pending		96
Total membership as of Dec. 9, 1943		1601

The list of those in the armed forces exempt from payment of dues continues to expand.

Journal subscriptions total 2029, a loss of 90 since last year, due mainly to our inability to send Journals overseas. Prior to the war the JOURNAL went to 53 foreign countries; today it goes to 24 countries mostly in this hemisphere. There is considerable loss of revenue from subscriptions, which coupled with the remission of dues and the advance of approximately $5000 towards the publication of Index VI has constituted a serious drain on the current assets of Association and Journal.

JOURNAL costs have of necessity increased but we are fortunate in having a publisher who has been extremely considerate and helpful in the face of rising costs and shop difficulties. Despite increased costs our engraver has not increased prices.

The Permanent Fund continues to increase from interest accruals and is now over $25,000. It may be necessary to draw on this fund during the ensuing war period. The Association should feel gratification that such a fund has been developed, conserved and is available to meet any emergency likely to arise.

There are well over 800 entomologists in the armed forces and the U. S. Public Health Service. This means that essential services on the home front are cut to the point where further drains might easily result in reduction of food and fibre. Teaching staffs, through reduction in students will be able to cope with their problem and many are assisting in the research and extension activities.

The problem of post war relocation of personnel should engage the attention of this Association. Possibly this is the time for setting up the machinery for some form of employment agency within the Association, that can begin to accumulate and classify the background, skills and experience of all its members, but particularly those in the armed forces. Much of this information is in the war work questionnaire but needs supplementing and classifying.

ERNEST N. CORY,
Secretary-Treasurer

College Park, Md., December 4, 1943

Dr. E. N. Cory, Secretary
American Association of Economic Entomologists
College Park, Maryland

Dear Dr. Cory:

I have made an examination of the accounts and financial records of the American Association of Economic Entomologists for the fiscal year ended November 30, 1943 and, without making a detailed audit of the transactions, have tested the accounting records of the association and other supporting evidence, by methods and to the extent deemed appropriate.

In my opinion the accompanying statements of receipts and disbursements of the association and the permanent fund present fairly the results of its operations for the fiscal period and the cash positions of its funds at November 30, 1943.

Respectfully submitted,
CHARLES L. BENTON, JR.,
Certified Public Accountant

REPORT OF THE RESOLUTIONS COMMITTEE

Your Committee on Resolutions begs to submit the following report:

Whereas members of the American Association of Economic Entomology have enjoyed a very successful joint meeting with the Entomological Society of America and are deeply grateful to various agencies and organizations who have made this possible, be it therefore resolved that thanks be extended to—

(1) The local Committee on Arrangements for their careful planning.

(2) The Program Committee for their efforts in arranging the very interesting and valuable program.

(3) The Management of the Deshler-Wallick Hotel for their courtesies in providing a suitable meeting place.

(4) The members of the U. S. Army, the Navy and the Public Health Service and to MAJOR R. H.

OZBURN of the Royal Canadian Army Medical corps for their attendance and contributions to the program.

Resolved: That a Committee of three be appointed and charged with the duty of codifying the regulations and statements of policy which have from time to time been enacted. That the report of this Committee be submitted to the Executive Committee for approval and shall then be published in THE JOURNAL OF ECONOMIC ENTOMOLOGY.

That the Committee be further instructed to draft such amendments for modification as may seem to be necessary to clarify obscure or conflicting points and to cover needed regulations not now existing and to present such proposals at the next regular meeting of the Association. That this Committee be instructed to formulate for each Association Committee a Charter of duties as indicated by the constitution and actions of the organization.

Whereas it is known to all of us that an adequate supply of agricultural insecticides is vitally needed for protection of food crops from insect losses and whereas the role of food in the war is assuming ever increasing importance and whereas legislation is pending or proposed in several States and in Congress that would require coloration of white powdered insecticides and combinations, the enforcement of which is believed to be impossible under present conditions because of shortage of dyes and the lack of information on the effect of dyes on toxicity, and whereas the confusion resulting from such legislation might jeopardize the needed supply of these materials, therefore be it resolved that members of this Association be urged to give thoughtful consideration to this problem and take such immediate action as seems advisable to inform their Representatives in State and National government of the possible diasterous effect of this legislation on agricultural production.

Resolved that the Association regrets the passing of the fourteen members who have died during the past year and takes particular cognizance of the fact that four of those had served as President of the Association.

C. E. PALM
CLAY LYLE
GEO. M. LIST

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee presented the following names of members nominated for the offices named and the terms indicated:

President: E. O. ESSIG
First Vice-President: S. A. ROHWER
Executive Committee: A. S. HOYT (1945)
Committee on Common Names of Insects: U. C. LOFTIN (1945), J. S. HOUSER (1945)
Committee on Membership: GEORGES MAHEUX (1945)
Publications Committee: ALVAH PETERSON (1946)
Program Committee: A. M. BOYCE (1946)
Committee on Codling Moth: LEONARD HASEMAN (1945), L. F. STEINER (1944), B. F. DRIGGERS (1944)
Committee on Insecticide Terminology: ROY HANSBERRY (1945)
Committee on Popular Entomological Education: J. O. PEPPER (1946)
Committee on Cooperation with Pest Control Operators: E. G. LINSLEY (1946)
Committee on Relation of Entomology to Conservation: G. C. DECKER (1945), F. E. WHITEHEAD (1945)
Committee on Grasshopper Research: CLAUDE WAKELAND (1946), H. DOUGLAS TATE (1946)
Board of Trustees for Permanent Fund: H. G. CRAWFORD (1944)
Trustee for Crop Protection Institute: A. M. BOYCE (1946)
Representative to National Research Council: J. I. HAMBLETON, Washington, D. C.
Councillors of the American Association for the Advancement of Science: LEONARD HASEMAN (1944), ROGER C. SMITH (1945)
Editorial Board, JOURNAL OF ECONOMIC ENTOMOLOGY: L. M. PEAIRS, Editor, HARRY B. WEISS, Associate Editor, E. N. CORY, Business Manager

Where such action was necessary the Nominating Committee designated Chairmen for the various committees; these are indicated in the Official Roster of the Association.

Submitted by F. A. FENTON
G. F. MACLEOD
WM. MIDDLETON, *Chairman*

STATEMENT OF RETIRING PRESIDENT (1943)

As a result of the unusual procedure followed in the election of officers for 1943, no designation of committee chairmen was made by the Committee on Nominations. The chairmen of the various standing committees were therefore designated by the President of the Association. They are as follows:

Committee on Common Names of Insects: RAY HUTSON
Committee on Membership: GEORGES MAHEUX
Publications Committee, JOURNAL OF ECONOMIC ENTOMOLOGY: J. S. HOUSER
Program Committee: W. H. WHITE
Committee on Codling Moth: L. F. STEINER
Committee on Insecticide Terminology: R. H. ROBINSON
Joint Committee for Promotion of Official Entomology: A. M. BOYCE
Committee on Popular Entomological Education: T. H. PARKS
Committee on Cooperation with Pest Control Operators: A. S. HOYT
Committee on Relation of Entomology to Conservation: F. P. KEEN

Committee on Grasshopper Research became a standing committee by the action taken at the San Francisco meetings. It, however, was not included in the ballot for election of 1943 officers. The Committee was reappointed by the President with H. C. SEVERIN as chairman.

The following committees appointed by former President Weiss were continued with chairmen and membership as indicated:

Joint Committee on Military Entomology: F. C. BISHOPP, *Chairman*, E. N. CORY, ROBERT MATHESON.

Joint Committee on Coordination of Entomology with the War Effort: E. F. PHILLIPS, *Chairman*, P. D. SANDERS, L. M. PEAIRS, J. S. HOUSER, A. S. HOYT, E. N. CORY, S. A. GRAHAM.

The two following committees were continued to make a final report to the Association. Although these committees submitted reports which were published in the February 1943 JOURNAL, the reports require Executive Committee consideration and have not been acted upon by the Association:

Committee to Study all Phases of the *Publication ENTOMA*: F. L. CAMPBELL, *Chairman*, C. C. HAMILTON, CLAY LYLE, J. S. HOUSER, A. M. BOYCE, NEELY TURNER, ROY E. CAMPBELL.

Committee on the Section of Plant Quarantine and Inspection: B. A. PORTER, *Chairman*, Z. P. METCALF, T. H. FRISON, A. M. BOYCE.

The following committees were not reappointed on the recommendation of the committee or the committee chairmen:

Committee on Insecticide Supply Situation

Committee on Model Insecticide and Pest Control Laws

Committee on Estimating Insect Damage and Populations

The following new committees were designated:

Committee on Local Arrangements: T. H. PARKS, *Chairman*, NEALE F. HOWARD, D. M. DELONG.

Committee on Nominations: WM. MIDDLETON, *Chairman*, F. A. FENTON, G. F. MACLEOD.

The mail ballot omitted names for the representative to the National Research Council to replace C. E. Palm, whose term expired in June 1943. J. I. Hambleton was designated to fill this vacancy in view of his election at the San Francisco meetings before the expiration of Dr. Palm's term.

In June the Secretary sent letters to members of the Executive Committee, to the secretaries and chairmen of sections and branches, to past Presidents, in the general vicinity of Washington, D. C., to the program committee and past program committee in the eastern area, to a number of committee chairmen, and to a list of individuals designated by Secretary Mickel of the *Entomological Society of America*, asking their opinion on the desirability of holding the 1943 meeting and inviting attendance at a meeting on June 29 to discuss this subject. Eighteen attended the meeting and replies were received from 20 others who were unable to attend. As a result of this meeting, the Executive Committee decided to hold the 1943 meeting with a program consisting of invitation papers and discussions based on entomology and the war.

J. J. Davis was designated to represent the Association at the funeral of W. P. Flint, C. E. Palm at the funeral of L. S. McLaine, and J. T. Creighton and W. G. Bruce at the funeral of Wilmon Newell.

Cancellation of the 1942 meeting made it more difficult to carry on the affairs of the Association than normally as there was no background of discussion and no opportunity for general exchange of opinions which such a meeting affords. The President and the Executive Committee have taken such actions as seemed necessary to keep the affairs of the Association moving smoothly in spite of this handicap.

I wish to thank the members of the special and standing committees for their activity on behalf of the Association and to express my appreciation for the support of the membership.

P. N. ANNAND

REPORT OF THE COMMITTEE ON MEMBERSHIP

Your committee begs leave to submit the following report:

The committee desires to place on record the regrets of the Association on occasion of the deaths of the following members during the period covered by the report and to extend the sympathy of the membership to the surviving relatives and friends of the deceased:

Charles L. Stracener, *Baton Rouge, Louisiana*, August 12, 1941.

Arthur Hinton Rosenfelt, *Blacksburg, Virginia*, October 6, 1942

Lester E. Gibson, *Greenfield, Massachusetts*, November 14, 1942

William Hunter Volck, *Watsonville, California*, January 12, 1943

Dillard Wister Grimes, *Durant, Mississippi*, February 12

William Albert Hoffman, *San Juan, Puerto Rico*, April 4

Wesley Pillsbury Flint, *Urbana, Illinois*, June 2

John Calhoun Hamlin, *State College, Mississippi*, June 8

Leonard Septimus McLaine, *Ottawa, Canada*, July 20

Elmer Darwin Ball, *Tuscon Arizona*

George Ethelberg Sanders, *Richmond Hill, New York*, August 17

Hugh Knight, *Glendora, California*, October 9

Wilmon Newell, *Gainesville, Florida*, October 25

All the above were members of the Association. In addition the Committee notes with regret the death of Frank E. Lutz, a friend and colleague. (This report may be supplemented by adding the name of Ephrain Porter Felt who died within the week following the report at Stamford, Connecticut, on December 14—Ed.)

The Committee also recommends for election to membership in the Association the following applicants, 96 in number, whose credentials have been examined and approved:

John W. Balock, Apartado No. 3, Colonia Anahuac, Mexico, D.F.

Ralph C. Barnes, Box 210, Jacksonville, Fla.

John H. Beacher, 22A, So. 16th St., Allentown, Pa.

S. H. Bear, Box 255, Anna, Ill.

Fern R. Bell, Div. of Fruit Insects, Beltsville, Md.

C. R. Blair, 39 Eastwood, Alexandria, La.

William G. Bodenstein, Hq. First Air Task Force, APO 503, c/o P. M., San Francisco, Calif.

Joseph N. Borglin, 215 W. 37th St., Wilmington, Del.

C. Verne Bowen, 111 Northbrook Lane, Bethesda 14, Md.

James L. Brann, Jr., 715 State St., Ithaca, N.Y.

Charles H. Brett, Stillwater, Okla.

Elmer C. Carlson, 1410 Virginia St., Mt. Vernon, Wash.

George F. Carter, 2239 Commonwealth, St. Paul, Minn.

Walter Cholerton, 4126 Chester Ave., Philadelphia, Pa.

William H. Craft, Box 340, Honolulu, T.H.

George H. Culpepper, Box 3391, Orlando, Fla.

L. F. Curl, Box 798, San Antonio 6, Tex.

Lionel Daviault, Ministere des Terres et Forets, Quebec, Can.

Clifton J. Davis, Waimea, Kauai, Hawaii, T.H.
Samuel C. Dews, Maj., Sn. C., Med. Br., Hq. 4th Service Comm., Atlanta, Ga.
Emile B. Dubuisson, Stafford, Tex.
Harold Elishewitz, Chem. Sec., Res. & Devel. Br., Military Planning Div., Office of Quartermaster, Temp. Bldg. A, 2nd & T. Streets, S.W. Washington, D.C.
John F. Fales, 1917 Elkhart St., Silver Spring, Md.
Ellsworth H. Fisher, 1321 Milton S.., Madison, Wis.
Elmer E. Fleck, B.E.P.Q., Beltsville, Md.
Charles A. Fleschner, 5876 Grand Ave., Riverside, Calif.
John M. Frederick, P. O. Box 935 Winter Haven, Fla.
Ted B. Gallion, St. Dept. of Agr., Library Bldg., Merced, Calif.
J. B. Garrett, Ext. Dept. Louisiana State Univ., Baton Rouge, La.
Wilbur A. Gersdorff, McLean, Va.
Archie L. Gibson, 1312 Lakeside Ave., Coeur d'Alene, Idaho.
Fred M. Gordon, Nassau Co. Farm Bureau, Mineola, N.Y.
Harry K. Gouck, 6 Palm Ave., Savannah, Ga.
J. Linsley Gressit, 150 Fifth Ave., Rm. 904, New York, N.Y
Samuel J. Guerther, 601 Quackenbos St., Washington, D.C.
C. A. Hamsher, 11203 Hatteras St., N. Hollywood, Calif.
Elizabeth E. Haviland, Ent. Dept., Univ. of Md., College Park, Md.
L. S. Hitchner, 285 Madison Ave., New York, N.Y.
R. H. Handford, Box 250, Brandon, Man., Canada.
Paul Hoidale, Harlingen, Tex.
C. R. Hunt, Box 662-A, Dryden, Wash.
Frank Irons, 2021 Adams St., Toledo, Ohio.
Max Isbill, 3200 Tulane Ave., New Orleans, La.
Donald R. Johnson, 6409 Takoma Ave., Chicago 30.
Errol H. Karr, Box 4102, Portland, Ore.
J. P. LaDue, Citrus Expt. Station, Riverside, Calif.
Stanley H. Logan, Comstock Hall, Cornell Univ., Ithaca, N.Y.
George F. Leonard, 1010 Columbia Bldg., Louisville, Ky.
David W. Lynch, 350 N. Clark St., Chicago, Ill.
James McConnon, c/o McConnon & Co., Winona, Minn.
C. D. McLeroy, College Station, Tex.
H. Dewey Mann, 5701 Pontiac Ave., Berwyn Heights, Md.
Wallace F. Majure, Florence, S.C.
Nuri S. Malih, Dept. of Ent., Univ. of Calif., Berkeley
John G. Matthysse, Cornell Univ., Ithaca, N.Y.
Joe Milam, Box 126, Clarksville, Tenn.
Wallace C. Mitchell, 213 S. HazelAve., Ames, Ia.
Neal F. Morehouse, 205 Fourth Ave., Charles City, Ia.
Frank C. Morrison, MacDonald College P. O., Quebec Prov., Can.
J. E. Morrow, Aluminum Ore Co., East St. Louis, Ill.
Thomas D. Mulhern, Rutgers Univ., New Brunswick, N.J.
Richard C. Oakley, 25 River St., Hoboken, N.J.
Kellie O'Neill, 2210 Nueces St. Austin, Tex.
H. W. O'Kane, Pa. Salt Co., Takoma, Wash.
Theodore Oser, 315 Peachtree St., N.E. Atlanta, Ga.
Howard B. Owens, 5-D Parkway Rd., Greenbelt, Md.
Nellie M. Payne, American Cyanamid Co., Boston Post Rd., Stamford, Conn.
Robert L. Peffly, Dept. of Ent. & Zool., Ohio State Univ., Columbus, Ohio.
Max A. Perrot, Geigy Inc., 89–91 Barclay St., New York, N.Y.
William L. Popham, B.E.P.Q., Washington, D.C.
Charles Pomerantz, Bell Exterminating Co., 200 Hudson St., New York, N.Y.
John E. Porter, 4102 29th St., Mt. Ranier, Md.
David D. Questal, 1920 Parkwood Ave., Toledo, Ohio.
Robert E. Rieder, State College, Corvallis, Ore.
Milton S. Schlechter, B.E.P.Q., Beltsville, Md.
Lincoln B. Scott, Box 126, Clarksville, Tenn.
Herbert C. Secrest, Rm. 870, 623 N. 2nd St., Milwaukee, Wis.
Carl A. Setterstrom, 30 East 42nd St., New York, N.Y.
A. T. Sievers, B.E.P.Q., Beltsville, Md.
Charles L. Smith, Rutgers Univ., New Brunswick, N.J.
Dwight R. Smith, 9022 Fairview Rd., Silver Spring, Md.
H. V. Smith, 1910 Univ. Ave., St. Paul, Minn.
Laurence H. Snyder, B-2 Bldg., Ohio State Univ., Columbus, Ohio
Helen Sollers, 1218 Floral St., N.W. Washington, D.C.
Robert Staples, 33 Olive St., Northampton, Mass.
Donald F. Starr, Apartado 3, Colonia Anahuac, Mexico, D.F.
Edward A. Steinhaus, Rocky Mt. Lab., U.S.P.H.S., Hamilton, Mont.
J. Harvey Sturgeon, 1112 E. Broadway, Louisville, Ky.
Oscar E. Tauber, Dept. of Zool & Ent., Iowa State College, Ames
Doyle J. Taylor, Bay Co. Health Dept., Panama City, Fla.
D. C. Thurman, 306 E. 11th St., Austin, Tex.
Horace V. Wester, National Capital Parks, Dept. of Interior, Washington, D.C.
Raymond G. White, Rt. 2, Box 1, Chico, Calif.
Willis W. Wirth, 545 NE 32nd St., Miami, Fla.
Walter L. Worthy, Box 87, Hueneme, Calif.
John M. Wright, 125 Natural Resources Bldg., Urbana, Ill.

Respectfully Submitted
NEALE F. HOWARD, *Acting Chairman*

REPORT OF THE COMMITTEE ON COMMON NAMES OF INSECTS

There are now on file with the chairman of your committee, fifty-three insects names for assignment of or changes in common names representing those proposals submitted since the list published on pages 83–101 of the February 1943 issue of this JOURNAL.

It is proposed that a March 1, 1944 deadline be established for additional proposals for inclusion in a list to be submitted to the membership during the summer of 1944.

R. T. COTTON
B. G. THOMPSON
JOSEPH WILCOX
E. H. STRICKLAND
CLAUDE WAKELAND
RAY HUTSON, *Chairman*

REPORT OF PUBLICATIONS COMMITTEE

The Committee recommends the adoption of the following change in the by-laws of the Association governing the Publications Committee:

> That Article III Section 2 be amended to read: The Publications Committee shall consist of seven members to be elected for terms not to exceed three years in duration. Any member may be re-elected for one additional period.

In the report of the Publications Committee for 1941, published on page 133 of the JOURNAL OF ECONOMIC ENTOMOLOGY February 1942, the suggestion was made and adopted that the rule, which requires the payment of $6.00 per page for JOURNAL papers in excess of the six-page limit, be rescinded for a 2-year trial period. Further, the Publicatons Committee for 1943 was instructed ". . . to study the effect of the change on the length and quality of JOURNAL papers and recommend whatever additional changes experience may dictate."

The present committee has made such a study. We have found that during the trial 2-year period the average length of papers has not increased materially and that the publication demands on the JOURNAL have not yet been excessive. Moreover, it has been possible to accept for publication several valuable papers which otherwise might have appeared elsewhere.

Although the trial plan has increased the need for editorial discretion, we believe that in the aggregate it has resulted in the betterment of the JOURNAL, therefore, we recommend that the trial period for the suspension of the six-page limit rule be extended to operate through 1944 and 1945. However, we suggest that papers in excess of six pages be scrutinized with extreme care and that the editor and Publications Committee exercise full discretion.

The Critical Review on Attractants and Repellents under preparation by W. M. Hoskins is nearly completed. The Committee recommends prompt publication after the receipt of the manuscript.

Printing of the JOURNAL during 1943 has been frought with numerous difficulties due to war conditions, nevertheless the quality of the printing has not suffered. The total number of pages will slightly exceed the 1942 total.

The Committee commends the JOURNAL officers, and particularly the Editor, for a job well-done.

The Committee wishes to express its appreciation to the George Banta Publishing Company, the printers of the JOURNAL and the G. R. Grubb Company, engravers for excellent services rendered during a year of great difficulty.

The Committee recommends to the Nominating Committee, the following list of JOURNAL officers to serve during 1944.

Editor	L. M. PEAIRS
Honorary Editor	E. P. FELT*
Associate Editor	HARRY B. WEISS
Business Manager	ERNEST N. CORY

Respectfully submitted,

ROGER B. FRIEND
E. F. PHILLIPS
A. B. BAIRD
C. H. RICHARDSON
C. M. PACKARD
M. A. STEWART
ALVAH PETERSON
DWIGHT ISLEY
B. A. PORTER
W. E. DOVE
J. S. HOUSER, *Chairman*

* Deceased, December 14, 1943.

REPORT OF THE COMMITTEE ON CODLING MOTH FOR 1943

In recent years the Committee on Codling Moth has sponsored conferences of workers interested in codling moth control and has arranged with the Bureau of Entomology and Plant Quarantine for the collection, preparation, and redistribution of an annual poll of information on current research. In 1941 and 1942 the Committee also suggested those lines of research which it considered most important.

By correspondence your Committee has voted unanimously against having a conference this year. Members of the Committee were all agreed however, that the pool of information was of very great value to all workers and should be continued and arrangements were again made with the Bureau of Entomology and Plant Quarantine for its collection, preparation and distribution. This is the eleventh in an unbroken annual series and the Committee hopes that all codling moth investigators or research organizations in Canada and South Africa as well as the United States will contribute to the pool.

The majority of the Committee feels that the suggested lines of codling moth research given in the 1942 report should be again presented with some slight revision. These suggestions follow.

1. Abstract all published information on codling moth studies and observations and make copies of the complete abstract available to those persons interested in codling moth research. It is suggested that the Bureau of Entomology and Plant Quarantine take the lead in this undertaking.

2. Continue research on substitutes for lead arsenate. This compound is inefficient in regions where codling moth injury is severe, is often injurious to fruit and foliage and has been suspected of reducing the set of fruit. Scarcity of the basic materials from which lead arsenate is manufactured during the war period is an added reason for continuing and intensifying the search for substitutes, with special emphasis on nicotine bentonite.

Studies of methods of fortifying lead arsenate as a larvicide should continue with emphasis on the development of chemicals that can be added to lead arsenate sprays to destroy other stages of the insect, particularly the egg and adult.

3. The Committee feels that more attention should be devoted to the study of ways and means of destroying the overwintering larvae and spring pupae; that this is a field of study which has barely been touched upon and if a reasonable proportion of the total research work now being done was devoted to this phase of the problem worth while results might be obtained.

4. Further attention should be given to the evaluation of strains within regional orchard areas. Studies are also needed to answer the question: Can quick acting stomach poisons or contact insecticides lead to the development of resistant or hardier strains?

5. Fundamental studies are needed on physiology with special emphasis on the way insecticides destroy the different stages of the insect or influence the population. In this connection the effect on larvae already inside the apple should not be overlooked. Is the reproductive capacity of the insect or its rate of development affected? Some of the many new materials being tested as insecticides (usually only as ovicides and larvicides) may have entirely unsuspected effects in other ways that might be overlooked.

6. In studies on the habits and behavior of the in-

sect special emphasis should be placed on (1) the relation of the time of moth emergence or moth flights and the time when peaks of larval attacks actually occur, (2) the effects of specific insecticides and adjuvants on the behavior of larvae, adults and natural enemies. Such effects as repellency and attractiveness to adults or larvae might increase or decrease control in limited tests but have little or no effect in large areas. It is also possible that changes in behavior might make the insect more susceptible to other means of control when used in conjunction with a particular insecticide.

7. The reasons for differences in the relative control value of certain insecticides in different regions should be given more attention. It is generally assumed the differences are largely caused by climate, but just how are they responsible? Conflicting reports from different workers may reduce confidence in research unless regional differences are known to exist and their importance emphasized.

8. Codling moth research may be improved by the development of more reliable technique in order to make it possible to evaluate properly the many variables with which we must contend. Some workers are limited by time and funds and yet are under extreme pressure for results and cannot give much attention to the ideal technique, or even use reliable technique if it requires more work. For this reason the publication of results should give adequate information concerning methods so that others can at least estimate the reliability of the results.

9. The possibilities of biological control should receive more attention.

10. The majority of the Committee feels that entomologists have not taken due advantage of the factor of climate, particularly temperature, in the over all problem of codling moth control. It is common knowledge that in nearly every apple growing state or region there are areas of zones of intensity of codling moth attack. The intensity of attack is generally related to the number of broods per season and this in turn is governed to a large extent by the mean annual temperature during the apple growing season. Thus we find different areas where the codling moth is one, two, three or even four brooded and it is in the three and four brooded areas where the greatest difficulty in control is experienced. It is suggested, therefore, that entomologists in collaboration with horticulturists consider the advisability of gradually shifting apple production from the three and four brooded areas to the one and two brooded areas.

11. Entomologists should give more attention to the problem of rotation of apple plantings, either by rotating apples with apples or apples with other fruits, as a factor in the control of codling moth. This would seem to be particularly worthy of study in the three and four brooded areas. It is a general observation that codling moth is more easily controlled on younger and smaller trees. In this connection it would seem worth while to study the possibilities of the dwarf and semi-dwarf stocks in areas of severe codling moth attack.

12. There is a need for additional work by entomologists in cooperation with agricultural engineers and spray equipment manufacturers looking toward the development of more efficient machinery for applying sprays. One of the big items in the cost of apple production is the labor and equipment necessary to apply the number of sprays found necessary for adequate control with existing spray combinations.

The Committee will welcome any suggestions from members of the Association regarding ways in which its usefulness can be increased.

BYRLEY F. DRIGGERS — W. S. HOUGH
L. G. GENTNER — GEORGE M. LIST
EDWIN GOULD — L. F. STEINER, *Chairman*

REPORT OF THE COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

During 1943 entomology competed in the news with that from the battle fronts and insects stories accepted for publication in non-technical journals had to carry information of major public interest. The year was also noted for the reduction of paper allocated for newsprint. These facts contributed to make it more difficult than usual for publishers to devote the usual amount of space to such stories.

In addition to newspapers, the radio has recently come to fill an important place in informing the public on insect problems and their solution. Extension entomologists have revised their projects to make them more nearly fit in with the food goals as announced by the Secretary of Agriculture.

During a global war there is danger of new pests getting established in this country through the movement of planes, ships, war supplies and men. This possibility is not being ignored, but education of the public to the seriousness of new and unreported outbreaks, and the need of bringing them to the attention of entomologists, will do much to prevent their establishment and spread.

Many entomologists have enlisted in the armed services and a considerable number of these are serving directly in their field of science to protect our fighting forces against diseases carried by insects. Too little publicity has been given to this and the public at large is not well informed on the extent to which entomologists are entering into the protection of the health and comfort of our men on far away fronts.

On the home front, the public is eager for information on better methods of protecting our food and fiber crops and of our stored products against insect depredations. The entomologists have released many stories on these problems during the year and have outlined methods of procedure that bring about increased production of badly needed materials. Examples of this are; the campaign in most states that has been waged against the ox warble or cattle grub; the protection of orchards and vegetable gardens from insect losses; the protection of stored foods from contamination or destruction by stored product insects; also the organized effort to protect cotton for its oil, feed and fiber contribution. The methods utilized have been; through the use of the press, radio, farm papers, special prepared state and federal circulars and leaflets, national garden magazines, commercial trade journals, news letters and handbooks supported by insecticide and fungicide manufactures, and the increased use of colored slides and moving pictures.

The U. S. Department of Agriculture and all of the state colleges and experiment stations have stepped up their efforts to inform the public on insect control. Up to the end of November the Bureau of Entomology and Plant Quarantine furnished 60 press releases covering 34 entomological subjects and 68 radio releases on 18 entomological subjects. Information on insects and their control in victory

gardens was incorporated in 13 of the weekly broadcasts of the National Farm & Home Hour, and one period on that broadcast was given over exclusively to a discussion of "Substitute Insecticides." Radio as a method of instruction has been used extensively by the state entomologists figures and definite measurements of which are impossible to obtain.

The Federal Extension Service, in cooperation with the state extension entomologists, assembled and circulated a pool of the best available 2 by 2 colored slides, gathered from many sources, and is having these duplicated, on order, for the use of the state and some private institutions that give entomological instruction. Between 4000 and 4500 of these duplicate slides are being made and distributed to entomologists who participated in the exchange and ordered slides through the pool.

The Bureau of Entomology and Plant Quarantine, as well as many of the state agricultural colleges have been issuing 2 or 4 page leaflets, or a small folder-type circular, many of them carrying colored photographs or cartoons. These carry condensed information expressed in simple terms and are so illustrated as to show the steps in the control operation. One of the best of this type of folder or booklet is the one entitled "War on Insects" and was prepared and illustrated completely by a sub-committee on Milk Production of the Committee for the Coordination of Entomology with the War Effort. This is so well illustrated as to require very little reading by the public and is being sold to large dairy product manufacturers to be distributed with their advertising literature. Over one and one-half million copies of this folder have already been sold to commercial firms and 1944 is expected to bring orders from many other companies.

Private industries, and especially the manufacturers of insecticides, have contributed their full share in getting out timely information, even to the extent of devoting entire issues of their trade magazines to insect control. At least three large insecticide manufacturers have taken and prepared moving picture reels for general educational use and have placed these at the disposal of county agents and special commodity or other public group organizations. These have aided greatly in educating the public as to the "why" of spraying and the importance of timeliness and thoroughness.

There are now appearing daily in some of the larger newspapers, syndicated articles carrying insect stories that appeal to young people. One of these appears in dailies that have a combined circulation of several million.

Moving picture theaters now carry shorts on nature stories including insects which are illustrated by the use of animated cartoons. We must remember also that occasional popular commercial films carry excellent stories of insect depredations such as the scourage of locusts that appears in the picture "Good Earth" and the mormon crickets in "Brigham Young."

Of all of the methods utilized by the entomologists for informing the public, the radio offers the most flexibility and probably the greatest service at the least expense and effort. Most state colleges have good state owned radio stations all of which are available at any time for the entomologist to use. An example of this was given at this meeting when three of our members here were interviewed yesterday on the radio and their message carried to the listeners on the daily farm and home hour. The making of transcriptions of insect control operations in the field, or laboratory, enables the entomologist to get his message sent to commercial stations in outlying cities that have a wide listening audience. Radio news script may be prepared well in advance of the opportune time for its use and placed in the hands of county agents who will be glad to read it during their periodic broadcasts at their local stations. Commercial radio stations are anxious to use entomological material such as spray service broadcasts and give it a regular time on the program.

Insect control has a popular place in the national defense program and entomologists should make use of their opportunity to inform the public of their science and its application to every day life.

Respectfully submitted

M. P. JONES
JOHN T. CREIGHTON
J. A. HYSLOP
T. H. PARKS, *Chairman*

REPORT FOR 1943 OF THE COMMITTEE ON COOPERATION WITH THE PEST CONTROL OPERATORS

In its report for 1942 the Committee included some features which in its belief should have a place in a law tore gulate the practice of pest control. Comments of pest control operators and entomologists were invited and it was stated the next report would contain a craft of a proposed law. With respect to this last the attitude of the Committee has undergone a change. Among the reasons for delaying the issuance of its proposed draft are (1) the question where it should be a responsibility of the Association to draft a law to regulate the practice of pest control and (2) the lack of consideration given its proposed draft by the National Pest Control Association. A draft of the proposed law was made available to the Secretary of that Association February 19, 1943 but the Committee has recently learned it did not reach the committee of the National Pest Control Association for cooperation with the entomologists until November 7, 1943.

The secretary of the National Pest Control Association believes it unwise to publish a proposed draft of a pest control law at this time. He asserts that it may lead to confusion, that it may contribute to immature legislation in some States, that it will not contribute to efforts to stabilize practices in the pest control industry and that pest control operators and entomologists have little time under war conditions to devote to consideration of this important matter. This Committee does not believe that publication of its draft of a proposed law will lead to immature legislation and it is convinced that there is no better way to develop a law to regulate the practice of pest control than to make available to pest control operators and entomologists a proposal in concrete form which can be studied, modified or strengthened and receive the tests which such legislation should have before it is offered to State law-making bodies. For the reasons previously stated however the Committee is not including the craft it has prepared inthe present report.

There is in the National Pest Control Association a committee which corresponds to this Committee in the American Association of Economic Entomolo-

gists. It has been noted that the belief exists on the part of some of the pest control operators that the two committees should function as a sort of joint committee. Just how the two groups would get together is not explained. This Committee endeavors to cooperate with the pest control operators. It furnishes copies of its reports to that organization before they are delivered to its own Association. On the other hand this Committee does not see the reports of the companion committee of the pest control operators until after they are delivered to the National Pest Control Association.

At the annual meeting of the pest control operators in 1943, the Committee on Cooperation with Entomologists included the following recommendation in its report:

"To work out a plan with the entomology departments of universities and experiment stations, whereby students in entomology who are looking forward to entering the commercial field would come to commercial operators during their vacations for practical training and experience. These students should be released from their courses around the last of April or first of May, in time to be included for the summer personnel of the commercial operator."

While this Committee believes that war has brought conditions at most colleges and universities that make this proposal practically unworkable at the present time it presents this recommendation of the pest control operators because of its possible interest to teachers who may be giving some thought to post-war plans.

It would greatly appreciate comments from the Association or the individual members relative to the responsibility of this Association for drafting such a law.

ROGER B. FRIEND
O. W. ROSEWALL
AVERY S. HOYT, *Chairman*

REPORT OF THE COMMITTEE ON THE RELATION OF ENTOMOLOGY TO CONSERVATION

Since this Committee was formed in 1937, it has repeatedly called attention to the need for greater recognition of entomological considerations in various conservation practices, and for fuller participation by entomologists in the planning of conservation programs in order that values accruing from such programs be not outweighed by losses resulting from increased insect damage (JOUR. OF ECON. ENT., Vols. 31, 32, 33, 34 and 36 No. 1). Some progress has been made in working out solutions for conflicts arising on specific areas and in limited conservation fields, but usually the entomologist is not consulted until the damage is critical and the problem is acute. The continuing need is for early recognition of possible insect dangers and the including of entomological advice in planning conservation programs to the end that serious mistakes may be prevented.

As a result of the Committee's report of last year, one chief of an important conservation division recognized that there was still need for closer correlation of their activities with the work of entomologists and welcomed suggestions for mutually constructive work. This at least is one concrete example of the type of cooperation which the Committee hopes can be developed with other conservation agencies.

At present, destruction of natural resources by War is the order of the day and scant thought is being given to conservation; but the increased waste of today will make conservation and renewal of natural resources doubly important in the post-war period. In order that entomologists shall be in a position to render their greatest service in restoring national wealth, we should start making plans today. The general field and need has been adequately covered in previous reports. We now need to advance from the general to the specific. What still needs to be done?

Your Committee recommends that its membership be increased to five members, each member to act as chairman of a subcommittee covering one of the five major conservation fields, so that each of these fields may be carefully studied and specific recommendations made as to critical problems and actions which might be taken with the appropriate agencies operating in these fields. The major conservation fields and typical problems are as follows:

1. *Soil conservation and erosion control.*

Typical problems include white-fringed beetle vs. kudzu; grasshoppers vs. soil-binding plants; wheat-stem sawfly vs. strip farming; pale western cutworm, European corn-borer, etc. vs. cultural practices to prevent erosion.

2. *Water conservation and flood control.*

Typical problem includes check dams vs. mosquito control.

3. *Wildlife conservation.*

Typical problem includes maintenance of wild fowl habitats vs. mosquito control.

4. *Forest conservation.*

Typical problems—methods of cutting which increase beetle damage, planting of pure stands which may develop defoliator epidemics.

5. *Food crop conservation.*

Typical problem—Ever-normal-granary vs. stored products insects.

Your Committee recommends that each of these major fields be studied to determine (1) What entomological problems exist that are not now recognized and being studied by entomologists and conservation agencies; (2) Specifically what conflicts need to be composed between conservation and insect-control objectives; (3) What research and education needs to be undertaken to develop workable solutions and compose differences of viewpoint; (4) What agencies should be encouraged to include entomological considerations in their post-war conservation plans?

Your Committee recognizes that a great deal is now being done by the federal and State entomologists in developing cooperative procedures with their respective conservation agencies. We believe, however, that each of the major fields of conservation need to be reviewed in a broad way to see what more should and can be done to obtain the fullest possible measure of entomological participation in all conservation programs, particularly now when plans for the post-war period are being framed. We recommend continuance and intensification of the Committee's work.

S. A. GRAHAM
H. H. STAGE
F. P. KEEN

REPORT OF THE CROP PROTECTION INSTITUTE FOR 1943

The various projects of the Institute have been intensively prosecuted during 1943. The research program, like almost everything else, feels the pressure of the war emergency. However, there has been no tendency to hurry a new product into distribution before its merits are well established. On the contrary, the companies for which the Institute administers research seem fully inclined to await adequate data.

A summary of Institute projects is as follows:

Armour and Company.—Our preliminary studies with soluble blood albumin, begun in 1941, continued in an exploratory way. It has been found that soluble blood albumin is a good wetting agent with nicotine sulphate in hard water, wherein soap does not operate satisfactorily. Also, a combination of soluble blood albumin and soya flour offers considerable advantages as a combined spreading agent and tenacity agent.

Carbide and Carbon Chemicals Corporation.—Fungicidal Investigations. Dr. Richard H. Wellman, working under the supervision of Dr. S. E. A. McCallan, has continued his extensive study of organic fungicides and bactericides. The company's laboratories have continued to synthesize new compounds, as suggested by the results secured with materials already under investigation. The project has included both spore tests, utilizing various pathogenes, and greenhouse tests based on techniques which Dr. McCallan and Dr. Wellman have worked out. Four technical papers have been published on methods and the interpretation of results. With the cooperation of Dr. H. W. Thurston, Jr., a large-scale field test of potatoes for control of late blight was carried out. Also, an extensive field test in control of apple scab was conducted.

The year's work has again contributed materially to an understanding of the relation of chemical structure to fungicidal activity.

Carbide and Carbon Chemicals Corporation.—Insecticidal Investigations.

These studies were continued at the Pennsylvania experiment station under the supervision of Dr. E. H. Dusham. A considerable part of the work was devoted to further experiments with toxicants for fly sprays. As a corollary a number of chemical compounds were examined as activators for pyrethrum.

The Floridin Company.—Composites of fullers earth and various inorganic substances have been under preliminary study. It appears that certain composites may have a use in certain directions.

The Geigy Company.—Dr. George R. Ferguson, who had been employed on the staff of the Oregon experiment station, was employed by the Institute as a full time investigator of the new compound, dichlor diphenyl trichlorethane. Since initial work had been carried on at the New Hampshire experiment station, and since facilities and cultures were available, Dr. Ferguson was assigned to New Hampshire, but with the proviso that he might be moved to some other location at times, if insect infestations made a temporary move desirable. Dr. Ferguson is carrying on a comprehensive study of this new compound with reference to agricultural pests.

General Chemical Company, Inc.—Various studies already in progress have been continued in 1943, including application of sulphur compounds for control of the tomato psyllid (in Colorado under the direction of Dr. George M. List); studies of various fungicides (in North Carolina under the supervision of Dr. Luther Shaw); preliminary studies of anthelmintics (under the direction of Dr. E. F. Waller, of the New Hampshire experiment station); and investigations of seed disinfectants, (in North Caroline under the supervision of Dr. S. G. Lehman).

The Mathieson Alkali Works, Inc.—Investigation of certain compounds as toxicants for fly sprays has continued from time to time in 1943. The company's research laboratory succeeded in eliminating a constituent which reduced toxicity. The resulting product gave good performance at a usable percentage in household spray kerosene. In a related project further attention was given to the fungicidal possibilities of a residue remaining from manufacture of the compound.

S. B. Penick & Company.—Based on work carried on independently at the Boyce Thompson Institute the alkaloid piperine, derived from blackpepper, was investigated to get further data on its performance as partial substitute for pyrethrins.

Röhm & Haas Company.—A large number of organic compounds produced in experimental quantities in the company's research laboratory has been under preliminary test. A considerable number of these give indications of promise. Utilizing the most promising, field tests were conducted in control of apple scab, tomato defoliation disease, black spot on roses, and celery blight. The experiments included both sprays and dusts. An elaborate investigation was carried on relating to the influence of concentration and gallonage on performance. Headquarters of these investigations are at the New Haven experiment station, under the direction of Dr. J. G. Horsfall. Dr. Wendell D. Henry is employed as research associate.

Socony-Vacuum Oil Company, Inc.—Preliminary studies have been under way to determine possible changes or improvements in the general purpose garden spray which this company manufactures. In addition, cattle spray formulae were given study at the Indiana station, under the supervision of Prof. J. J. Davis.

U. S. Industrial Chemicals, Inc.—This investigation is concerned with possible utilization of a by-product available in the company's manufacturing program. The work was set up at the New Jersey experiment station, under the supervision of Dr. Firman E. Bear. Dr. Robert S. Snell was employed as research associate.

W. C. O'KANE

REPORT OF COMMITTEE ON INSECTICIDE TERMINOLOGY

Activities of the committee during the past two years have sought to define and to describe various inorganic, synthetic organic, and plant insecticides, and to list preferable abbreviations of units of information. The pressure of other duties has prevented the committee from completing this program of work and progress only can be reported.

M. D. FARRAR
W. R. HORSFALL
C. H. RICHARDSON
R. C. ROARK
R. H. ROBINSON, *Chairman*

REPORT OF THE COMMITTEE ON COORDINATION OF ENTOMOLOGY WITH THE WAR EFFORT, DECEMBER 7, 1943

Most of the members of the two entomological organizations are familiar with much of the planning and duties suggested by the work of this Committee from its appointment in the Spring of 1942, through published reports and other means. Nobody, not even the members of the Committee, can evaluate the work as to extent or influence on the production program of the nation. Many of the project leaders named in earlier reports have reported specific progress to the Committee. Others, no less effective, have permitted their published recommendations to bespeak their efforts. In many cases the tasks undertaken by suggestion of the Committee so overlapped the regular duties of leaders and members of projects that there can be and should be no differentiation. Certainly all concerned have shared with all entomologists a desire to make useful all available information to those in immediate need of it and in such form as to be most helpful. That entomologists have made a sincere effort to make the work of their profession useful is not to be questioned.

The methods of transmitting needed information to those at the firing line of production has varied enormously, both as to scope of material and agencies utilized as assistance. In some instances the distribution has necessarily been localized and in other cases widespread, according to the nature of the problem itself. Some leaders have utilized established publication series, while others have discovered new agencies for disseminating entomological information. An outstanding example of such a new agency is the cooperative effort of several dairy firms for publicizing the work on Dairy Insect Control.

Several million copies of the very excellent brochure on pests of the dairy industry prepared by this project group have been distributed and is now available for use among dairy farmers, dairy stores and manufacturers of dairy products. In a few cases local circumstances have delayed carrying out the planned efforts so that there has been little to report. On the whole the quantity and quality of the work has been far beyond the early expectations of the Committee, and judging from the ardent endeavor so far, it may be anticipated that all project groups will continue the effort, not to accept an assignment made by others but to reach the goal set by their own determination.

Changes in Organization: The lamented death of two project leaders and other circumstances make it necessary now to consider some changes in organization. The Committee has not determined the personnel of project groups, and still leaves it to the decision of chairman to make such changes as conditions may now dictate.

Dr. Wilmon Newell was chairman for the South on Citrus Insect Control. His death made a reconsideration necessary, and since control of insects attacking citrus fruits is well covered by existing agencies in the various areas, and since there seems nothing that could be added by project efforts, the Committee has dropped this project.

Professor W. P. Flint was project leader for soy bean insects. This project is now placed under the guidance of Dr. George C. Decker.

It seems advantageous to combine the Hog Insect project with that on beef (horses) and sheep, giving it the name of Domestic Animal project, with Dr. W. E. Dove as chairman.

Professor Flint was also chairman of the Corn Insect project and did outstanding work in organization of this effort. The project is now placed under the chairmanship of J. H. Bigger, fortunately working in the same laboratory as did the late Professor Flint. It seems desirable also to establish as a new project Insects Attacking Sweet Corn (especially in the East), under the chairmanship of Dr. L. A. Carruth.

Sometime back chairmanship of the work on White Potato Insects in the East was transferred to Dr. W. A. Rawlins but was not previously announced.

Because of the change of the work on domestic animals, the project which Dr. W. B. Herms is chairman is now limited to Insects Affecting Man.

Since the project on Naval Stores impinges on work on other forest insects, and since there seems to be imminent a great increase in the importance of educational effort on the broader field, the project is broadened to include all forest insect problems, and the Committee requests its member, Dr. S. A. Graham, to cooperate with Dr. F. C. Craighead in a study of any changes incident to the new plan.

All new designations of project leadership remain subject to acceptance to assignments.

Quotas for 1944 production should be available shortly and all project chairmen should inform themselves of any changes in quotas as indicative of the urgency of effort in their respective fields.

Insects Pest Survey: Changes in conditions incident to the war make it especially important that at all times entomologists be aware of shifts in insect populations and regarding incipient outbreaks. We cannot too vigorously emphasize the handicaps imposed at a time like this by the restriction in scope and size of the Insect Pest Survey, resulting from severe reduction in financial support of this cooperative federal and state activity. Entomologists recognize the need for economy, but believe that they are in better position to appreciate the seriousness of such a change in the Survey than are persons unfamiliar with the usefulness of this undertaking. Persistent and concerted efforts should then be made to bring about a restoration of the Survey. The Committee proposes no avenue of approach, but leaves that problem to the Officers of the two organizations. It seems incumbent on all entomologists to urge that funds be restored, not only for restoration of the Survey to its former scope but for an ultimate increase in its scope.

New and Proposed Changes in Insecticide Regulations: The control of insect pests involving the use of insecticides may be seriously impeded by proposed conflicting laws and regulations dealing with coloring of insecticides with specific colors. Entomologists agree that distinctive markings may well be required, but believe that every effort should be made to prevent imposition of conflicting and impracticable regulations. Whatever regulations may ultimately be enacted, it seems especially important that they be uniform as between the states, and they they do not interfere with the distribution of insecticides in the present emergency.

Respectfully submitted,
E. N. CORY
S. A. GRAHAM
J. S. HOUSER
L. M. PEAIRS
E. F. PHILLIPS, *Chairman*

REPORT OF JOINT COMMITTEE ON MILITARY ENTOMOLOGY

Your Committee on Military Entomology has continued to function throughout the year. A considerable number of War-Work Training, Experience and Availability Forms have been executed by entomologists throughout the country and added to our files. These files carry the most complete information existing, in readily available form, regarding the training and experience of entomologists in this country. They have been accessible to the military authorities and have served in many instances as a basis for selecting men for entomological assignments in the military services.

The committee has maintained close contacts with the appropriate personnel officers of the Army and Navy, and Public Health Service, and the needs of those services for entomological personnel. It has aided many entomologists in civilian life to become commissioned for entomological work, or upon induction into the service to be assigned where they would have opportunity to perform work in entomological or related fields where their training and experience could be used to advantage. It has also lent assistance to the U. S. Public Health Service in procuring personnel for the important work of malaria control in war areas.

Special attention has been given to the matter of bringing to attention of appropriate officers men in the ranks who by training and experience would make good commissioned officers for entomological work or would serve effectively on special entomological assignments. At present more than 40 entomologists who were serving in the ranks have been commissioned in the Sanitary Corps. The number of entomologists commissioned in the Sanitary Corps of the Army now exceeds 200 and about 100 have been commissioned in the Hospital Volunteer Corps Service of the Navy. A large number of men with entomological training or experience have been attached to Malaria Survey and Control Units of the Army and Navy for oversea antimalaria work. The number of these units now activated exceeds 200.

Your committee has been concerned largely with aiding the military in the procurement of suitably trained men for entomological assignments, and to place entomologists in the military services where their training and experience can be utilized most effectively. In its actions in this regard, however, the committee has not lost sight of the entomological manpower situation as a whole and has endeavored to aid as much as possible in preventing the disruption of teaching, research, and especially extension and control activities in entomology. Thought has been given also to post-war problems in which the services of men now in medical entomological work in the Service may be utilized in that general field at the close of the war.

RALPH MATHESON
ERNEST N. CORY
FRED C. BISHOPP, *Chairman*

EXTENSION SECTION OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGY

The section on Extension Entomology met during the evening of December 8 with 50 persons attending. Dr. J. O. Pepper presided and after a few introductory remarks proceeded with the program.

The program consisted of talks from the extension workers from different parts of the United States. The main topics of discussion were the methods used in different sections in disseminating information to fruit growers, vegetable growers, Victory gardeners and general farmers. Methods used in putting on large scale demonstrations on the control of insects attacking livestock and insects attacking stored grain and rodent control was also discussed.

Mississippi and North Carolina reported on the use of 4H Club boys in collecting data on the infestation of the cotton boll weevil. J. Myron Maxwell, of North Carolina, was elected Secretary and Castillo Graham, of Maryland, was elected Chairman. The meeting adjourned at 2 A.M.

SECTION OF APICULTURE, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The section of Apiculture held a meeting at noon on December 7, 1943, in room 222 Deshler-Wallich hotel. Following the luncheon W. A. Price was elected Chairman *pro-tem* to serve in the absence of Chairman W. O. Park.

There was a single number on the program, an invitational paper entitled "Beekeeping in Two Wars" by Dr. E. F. Phillips. This interesting presentation furnished the substance and background for the lively discussions that followed.

In the business session at the conclusion of the program two officers were elected for the coming year. They were, J. A. MUNRO, *Chairman*, and W. A. PRICE, *Secretary*.

W. A. PRICE, *Secretary*

COTTON STATES BRANCH

SOUTHERN WAR CONFERENCE ON ENTOMOLOGY

The eighteenth annual meeting of the Cotton States Branch of the Association took the form of a war conference for the discussion of the entomological problems of the South as they affect the various phases of the national war problem.

The meetings were held in the Roosevelt Hotel in New Orleans on February 1, 2 and 3, 1944. Chairman O. E. Rosewall and Vice-chairman E. W. Dunnam presided over the several sessions.

The program consisted of symposia and discussions of several groups of problems. These included *Cotton Insect Control, Insects Affecting Man and Animals, Pests of Field Crops and Stored Grains or Seed, Fruit Insect Control, Insecticides and Machinery, Vegetable Garden Pests* and a general paper-reading session as well as a conference of extension entomologists and a general business session for the Branch.

Dr. E. O. Essig, newly elected President of the Association attended and addressed the group on the subject "Responsibilities of the American Association of Economic Entomologists in Connection with the War Effort."

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